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INDEX.

A.

	Page
Address, President's. Frank E. Merrill	100
Address of Welcome to Montreal. Mayor James Cochrane.....	420
Arched Vaulting. Discussion by Leonard Metcalf.....	398
ATKINSON, EDWARD.	
"Fuel: What We Don't Know About It ".....	180
"The Relation of Water Works Engineers to the Fire Service of Factories "	58

B.

BAKER, M. N. Discussion by.....	19
BANCROFT, LEWIS M. Treasurer's Report.....	111
BOOK NOTICES.	
"Ancient and Modern Engineering." Burr.....	126
BOWERS, GEORGE	
"Underground Water: Suggestions on How to Obtain and Care for It ".....	127
BRACKETT, DEXTER. Discussions by.....	144, 226, 228
BROOKS, EDWIN C. Discussions by	143, 199
BROOKS, FREDERICK.	
"The Folly of Reckoning by Gallons, Which Differ Widely in Canada and the United States, while all Countries have Identical Liters and Cubic Meters ".....	258

C.

CHASE, JOHN C. Discussions by.....	75, 200
"A Little Talk about Water Rates "	174
CLARK, HARRY W.	
"Removal of Color, Organisms and Odor from Water ".....	1
"Coal, Economy in the Use of, for the Production of Power." Ira N. Hollis.....	32
COCHRAN, ROBERT L. Discussion by.....	227
COCHRANE, JAMES, Mayor of Montreal.	
Address of Welcome.....	420
COFFIN, FREEMAN C. Discussions by	17, 142, 197
COGGESHALL, ROBERT C. P. Discussion by.....	68
COLLINS, MICHAEL F. Discussion by.....	172
"The Lawrence Filter ".....	288

59365

	Page
Color. "The Physical Properties of Water." Allen Hazen	21
"Removal of Color, Organisms and Odor from Water." H. W. Clark.....	1
Committee on Private Fire Protection, Report of.....	425
Composition Metal used on Metropolitan Water Works.....	205
Concrete. "Covering the Natick, Mass., Reservoir with a Concrete Roof." Frank L. Fuller.....	383
Constitution, Amendment to.....	421
COOK, J. H. Discussion by	229
"Covering the Natick, Mass., Filter with a Concrete Roof." Frank L. Fuller	383
Cost of Pipe Laying on Metropolitan Water Works.....	216
CRANDALL, F. H. Discussions by.....	82, 331, 424
Report of Committee on Private Fire Protection.....	425

D.

Dam. "The Echo Lake Dam at Milford, Mass." Leonard Metcalf.	146
DEAN, FRANCIS W. Discussions by.....	377, 414
Diaphanometer for Turbidity Determinations. R. S. Weston.....	27
DOANE, A. O. Discussion by.....	133
"Duties of Municipalities Regarding Water Supply." John O. Hall.	9

E.

"Echo Lake Dam at Milford, Mass." Leonard Metcalf.....	146
"Economy in the Use of Coal for the Production of Power." Ira N. Hollis.....	32
Editor of the Journal, Report of. Charles W. Sherman.....	114
Efficiency of Engines and Boilers.....	32
Election of Officers.....	119
"Electricity, Pumping by." F. H. Pitcher.....	349
"Engines, Waste Heat." Edward F. Miller.....	44
Executive Committee, Proceedings of	124, 234, 300, 430
Exhibits at Montreal Convention.....	427

F.

"Filter, The Lawrence." Michael F. Collins.....	288
Filtration, Experimental, at New Orleans.....	166
Fire Protection, Private, Report of Committee on.....	425
"Fire Service of Factories, The Relation of Water Works Engineers to." Edward Atkinson.....	58
Fire Services, Private.....	201
FULLER, FRANK L.	
"Covering the Natick, Mass., Reservoir with a Concrete Roof" .	383
Discussions by	143, 374
FULLER, WILLIAM B. Discussion by	412
"Fuel: What We Don't Know About It." Edward Atkinson.....	180

G.

	Page
GALE, JAMES M. Obituary.....	303
GIBBS, HARRY F. Discussion by.....	40
GOWING, E. H.	
" How I Reduce Pressure on a Gravity System".....	139

H.

HALL, JOHN O.	
" Duties of Municipalities Regarding Water Supply ".....	9
" The Reciprocal Obligations of the Management of a Water Supply System and the Community ".....	338
HAMMATT, E. A. W. Discussion by.....	198
HAZEN, ALLEN.	
" The Physical Properties of Water ".....	21
HOLLIS, IRA N.	
" Economy in the Use of Coal for the Production of Power ".....	32

I.

Ice, Formation of, in Montreal Water Works Aqueduct.....	274
--	-----

J.

JANIN, GEORGE.	
" History and Description of the Montreal Water Works ".....	272
Discussion on Montreal Water Works.....	378

K.

KENT, WILLARD.	
Report of the Secretary.....	108
KIMBALL, FRANK C.	
" Some Six-inch Meter Tests and How They Were Made ".....	305
KINNICUTT, LEONARD P. Discussion by.....	41

L.

Lead, Amount of, in Pipe Joints, Metropolitan Water Works.....	224
LESAGE, THOMAS W.	
" Service Boxes of the Montreal Water Works ".....	284
Discussion by.....	378
Lawrence, Mass. " The Lawrence Filter." M. F. Collins.	288

M.

McKENZIE, T. H. Discussion by.....	66
MACKSEY, H. V. Discussion by.....	72
MARTIN, CYRUS B. Obituary.....	125
MERRILL, FRANK E. Discussion by.....	228
President's Address.....	100
Portrait of.....	facing 100

METCALF, LEONARD.	Page
"The Echo Lake Dam at Milford, Mass."	146
Vaulted Coverings for Reservoirs and Filters. Discussion.....	398
Meters. "Some 6-Inch Meter Tests and How They Were Made."	
Frank C. Kimball.....	305
Metric System. Frederick Brooks.....	258
"Metropolitan Water Works, Pipes and Pipe Laying on the." C. M.	
Saville.....	203
"Milford, Mass., The Echo Lake Dam at." Leonard Metcalf.....	146
MILLER, EDWARD F.	
"Waste Heat Engines".....	44
Mississippi River, Character of Water of, at New Orleans.....	161
Montreal, Twenty-second Annual Convention at.....	418
Montreal Water & Power Co.'s Electrically Driven Pumps.....	349
"Montreal Water Works, History and Description of." George Janin	272
Discussion on.....	378
Mud Fuel. Edward Atkinson.....	180
"Municipal Use and Waste of Water." John Venner. Discussion..	268
"Municipalities, Duties of, Regarding Water Supply." John O. Hall,	9

N.

Natick, Mass., Concrete Roof for Reservoir. Frank L. Fuller.....	383
"New Orleans, The Water Supply of, and its Improvement." Robert	
Spurr Weston	157

O.

OBITUARY NOTES.	
James M. Gale.....	303
Cyrus B. Martin.....	125
Charles F. Parks	303
"Obligations, the Reciprocal, of the Management of a Water Supply	
System and the Community." John O. Hall	338
Odor } "Removal of Color, Organisms and Odor from Water."	
Organisms. } H. W. Clark	1

P.

PARKS, CHARLES F. Obituary.....	303
"Physical Properties of Water." Allen Hazen	21
"Pipes and Pipe Laying on the Metropolitan Water Works." Caleb	
Mills Saville.....	203
PITCHER, F. H.	
"Pumping by Electricity".....	349
"Power, Economy in the Use of Coal for the Production of." Ira	
N. Hollis	32
"Precision, Practical and Theoretical, in Every-day Life." William	
B. Sherman.....	52

	Page
"Pressure, How I Reduce, on a Gravity System." E. H. Gowing...	139
Pressure-reducing Valves	142
Private Fire Protection, Report of Committee on.....	425
Proceedings:	
December, 1902.....	97
January, 1903 (Annual Meeting).....	99
February, 1903.....	122
March, 1903.....	231
June, 1903.....	298
September, 1903 (Annual Convention).....	418
November, 1903.....	429
"Pumping by Electricity." F. H. Pitcher.....	349

R.

Rates. "A Little Talk about Water Rates." John C. Chase	174
"Reciprocal Obligations of the Management of a Water Supply System and the Community." John O. Hall.....	338
Report of the Editor of the JOURNAL.....	114
Secretary	108
Treasurer	111
Reservoir, Concrete Roof for, Natick, Mass.	383
RICHARDS, WALTER H. Discussion by.....	65

S.

SAVILLE, CALEB MILLS.

"Pipes and Pipe Laying on the Metropolitan Water Works."	203
Schoolhouses, Use of Water in, at Syracuse, N. Y.	268
Secretary, Report of. Willard Kent	108
"Service Boxes of the Montreal Water Works." T. W. Lesage.....	284
SHERMAN, CHARLES W. Report of the Editor of the JOURNAL	114
Water Works Statistics for the Year 1902.....	235
SHERMAN, WILLIAM B.	
"Practical and Theoretical Precision in Every-day Life."	52
SMITH, J. WALDO. Discussion by.....	143
SNELL, GEORGE H. Discussion by.....	64
Special Castings, Table of Dimensions and Weights of, to accompany "Standard Specifications for Cast-Iron Pipes and Special Cast- ings.".....	84
Statistics of Water Works for 1902	235
Subsidence, Effect of, on Mississippi River Water at New Orleans....	164

T.

TAYLOR, CHARLES N. Discussion by.....	134, 195
Test of Six-Inch Meters	305
THOMAS, ROBERT J. Report of Committee on Private Fire Protection,	425

	Page
TILDEN, J. A. Discussion by.....	332
Treasurer, Report of. Lewis M. Bancroft.....	111
Turbidity. "The Physical Properties of Water." Allen Hazen.....	21

V.

Vaulting. Discussion by Leonard Metcalf.....	398
VENNERS, JOHN.	
"Municipal Use and Waste of Water.".....	268

W.

WALKER, CHARLES K., President, Portrait of.....	<i>Frontispiece</i>
Discussion by.....	64
"Waste Heat Engines." Edward F. Miller.....	44
Waste of Water.....	268
"Water, Underground; Suggestions on How to Obtain and Care for It." George Bowers.....	127
Wells, Driven.....	127
WESTON, ROBERT SPURR.	
"The Water Supply of New Orleans and Its Improvement.".....	157
Discussion by.....	27
WINSLOW, C.-E. A. Discussion by.....	171
WINSLOW, GEORGE E. Discussion by.....	226

Table of Contents.

VOLUME XVII.—MARCH TO DECEMBER, 1903.

NO. 1.—MARCH, 1903.

Portrait of Charles K. Walker, President N. E. W. W. Association,	Page
	<i>Frontispiece</i>
"Removal of Color, Organisms, and Odor from Water," by H. W. Clark	1
"Duties of Municipalities Regarding Water Supply," by John O. Hall; with discussion.....	9
"The Physical Properties of Water," by Allen Hazen; with discussion,	21
"Economy in the Use of Coal for the Production of Power," by Ira N. Hollis; with discussion.....	32
"Waste Heat Engines," by Edward F. Miller; with discussion	44
"Practical and Theoretical Precision in Every-day Life," by William B. Sherman; with discussion	52
"The Relation of Water Works Engineers to the Fire Service of Factories," by Edward Atkinson; with discussion	58
Standard Specifications for Cast-Iron Pipe and Special Castings	84
Proceedings, December, 1902, Meeting	97
Proceedings, January, 1903, Annual Meeting	99
Portrait of Past-President Frank E. Merrill	<i>facing</i> 100
President Merrill's Address.....	100
Secretary's Report	108
Treasurer's Report	111
Editor's Report.....	114
Election of Officers.....	119
Proceedings, February, 1903, Meeting.....	122
Meetings of the Executive Committee	124
Obituary: Cyrus B. Martin	125
Book Notice	126

NO. 2.—JUNE, 1903.

"Underground Water: Suggestions on How to Obtain and Care for It," by George Bowers; with discussion.....	127
"How I Reduce Pressure on a Gravity System," by E. H. Gowing; with discussion.....	139

	Page
"The Echo Lake Dam at Milford, Mass.," by Leonard Metcalf.....	146
"The Water Supply of New Orleans and Its Improvement," by Robert Spurr Weston; with discussion	157
"A Little Talk about Water Rates," by John C. Chase	174
"Fuel: What We Don't Know About It," by Edward Atkinson; with discussion	180
Private Fire Services	201
"Pipes and Pipe Laying for the Metropolitan Water Works," by Caleb Mills Saville; with discussion	203
Proceedings	231

NO. 3.—SEPTEMBER, 1903.

Water Works Statistics for the Year 1902.....	235
"The Folly of Reckoning by Gallons, which Differ Widely in Canada and the United States, while All Countries Have Identical Liters and Cubic Meters," by Frederick Brooks	258
"Municipal Use and Waste of Water," by John Venner	268
"History and Description of the Montreal Water Works," by George Janin.	272
"Service Boxes of the Montreal Water Works," by T. W. Lesage	284
"The Lawrence Filter," by M. F. Collins	288
Proceedings, June, 1903, Meeting	298
Executive Committee Meetings	300
Obituary: Charles F. Parks.....	303
James M. Gale	303

NO. 4.—DECEMBER, 1903.

"Some 6-inch Meter Tests, and How They Were Made," by Frank C. Kimball; with discussion	305
"The Reciprocal Obligations of the Management of a Water Supply System and the Community," by John O. Hall.....	338
"Pumping by Electricity," by F. H. Pitcher	349
"Municipal Use and Waste of Water;" discussion	374
"History and Description of the Montreal Water Works;" discussion..	378
"Covering the Natick, Mass, Reservoir with a Concrete Roof," by Frank L. Fuller; with discussion	383
Proceedings: Twenty-second Annual Convention	418
November, 1903, Meeting.....	429
Executive Committee.....	430



CHARLES K. WALKER,
President of the New England Water Works Association.
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NEW ENGLAND WATER WORKS ASSOCIATION.

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REMOVAL OF COLOR, ORGANISMS, AND ODOR FROM WATER.

BY H. W. CLARK, CHEMIST OF THE MASSACHUSETTS STATE BOARD OF HEALTH.

[Read September 11, 1902.]

A very large amount of work has been done in this country during the last ten or twelve years, investigating the purification of water by sand filtration. A large part of this work has been directed to the study of efficient methods of removing bacteria from water, although in some instances the removal of clay, silt, etc., causing the water to have an objectionable turbidity, has been studied in connection with bacterial purification. It is my purpose in the present paper to describe briefly some filtration experiments, the main object of which was the removal from water of coloring matter, odors, and the organisms producing odors.

COLOR.

In all the experiments at the Lawrence Experiment Station of the State Board of Health upon the purification of water, the colors of the water applied to and of the effluents from the sand filters in operation there have been recorded. This color determination during the past twelve years has been made with Hazen's platinum standard.

The two largest experimental water filters at Lawrence, and the two that have been operated for the longest period, are known as Filters Nos. 3B and 8A. They were started in 1893, and contained at that time 5 feet in depth of sand, of an effective size of 0.24 millimeter. At the end of 1900 their depth was approximately one half as great as at the beginning of their operation. The average rate of filtration for the entire period of Filter No. 3B was about 2 500 000 gallons per acre per day, and that of Filter No. 8A

about 3 000 000 gallons per acre per day, although the rates varied considerably during the seven years. Both filters removed approximately 33 per cent. of the coloring matter in the water applied to them, although their efficiency varied considerably during different years and different periods of the same year.

Up to the year 1899 nearly all the work upon color removal at Lawrence had been simply incidental to other work and had been carried on with Merrimac River water only, from which, as I have stated, practically 33 per cent. of the coloring matter can, on an average, be removed by sand filtration. During 1899, however, some further experiments were begun. A large tank, holding some 8 000 or 9 000 gallons, was filled with the river water, and the color of this water was increased and varied by adding to it decaying vegetation of different kinds and in different amounts, as much water being run into the tank each day as was drawn from it for our filters. This work was of only slight importance during 1899, but was continued during 1900 and 1901, and the water in the colored water tank passed through many different phases during these years. Its color was increased, until during considerable periods it was several times as great as the color of the river water, and the nature of the materials added to produce this color caused the water to be at times, during the warm weather, in a state of fermentation, while at other times it was in a condition of equilibrium; that is, it would hold oxygen in solution instead of immediately using it.

A number of sand filters were operated, to which this highly colored water was applied, several of these filters receiving the water without preliminary treatment with chemicals, etc., while the water applied to others was first treated with chemicals of different kinds. By sand filtration alone we removed from 60 to 80 per cent. of the color of the applied water, month by month, when filtering at rates of from 1 000 000 to 2 500 000 gallons per acre per day, or an amount two and one-half times as great as is ordinarily removed from the Merrimac River water by filtration. It was quite noticeable, moreover, that the coloring matter in the water was more easily removed when the water obtained its color from old and decaying organic matter than when the color in the water was taken from fresher organic matter. It was also noticeable that the more active the state of fermentation in the tank containing the colored water, — that is, the more nearly the dissolved oxygen was exhausted, — the more completely could this water be decolorized by sand filtration,

if enough oxygen was introduced by aëration before filtration to last while the water was passing through the filter; that is, it was apparent that the intensity of the bacterial action in the tank of colored water had considerable to do in decreasing the amount of work to be performed by the bacteria in the filter.

These filters receiving Merrimac River water rendered highly colored by infusions of peat, hay, etc., not only removed a very much larger percentage of the coloring matter of the water than did the filters operated during the same period with untreated river water, but in many instances the color left in the water was less than the amount left in the effluents of the filters receiving river water. This seemed to indicate that not only the coloring matter added to the Merrimac River water by the decaying organic matter in the tank, but also the coloring matter primarily in that water when passing into the tank, was more easily acted upon and removed by filtration, after undergoing the fermentation active in the tank water during warm weather.

By the addition of alum or ferric chloride to the water, followed by filtration, practically all the coloring matter was removed, but it was necessary in some instances to add lime in order to aid in decomposing the amount of alum necessary to remove the coloring matter; that is, the alkalinity of the water was not sufficient. Various other chemical treatments were experimented with, especially potassium permanganate, this salt giving at times excellent results, but at others its entire reduction and precipitation were attended with considerable difficulty. When this occurred the color of the filtered water was increased instead of diminished.

Beginning in December, 1900, and extending until the end of January, 1902, a period of slightly more than thirteen months, experiments were carried on upon the removal of color, odor, and organisms from the Ludlow Reservoir water and the water from the canal which enters this reservoir. The reservoir and canal water are the chief supplies of the city of Springfield, in this state. This investigation was the joint work of the city of Springfield and the State Board of Health, and the method of experiment, the number and variety of filters, and the laboratory work were under my charge.

Ludlow Reservoir has an area of 445 acres, with an average depth of 13.7 feet, and its bottom is largely covered with a deposit of mud of considerable depth. The water from this reservoir has often caused considerable trouble to the city of Springfield, as enormous number

of microscopical organisms grow in it during the summer and impart tastes and odors to its waters. In this reservoir we seem to have on a large scale conditions somewhat similar to those prevailing in our tank of water at the experiment station just described, where mud, peat, decaying wood, etc., were used to add color and organic matter to water for experimental filtration. In the reservoir, with its muddy bottom, its decaying tree stumps, etc., there is in the warm weather not only a growth of *anabæna* and other organisms, but also a decided increase in the color of the water, and practically all of this coloring matter is in solution.

The average color of the water in the reservoir during the first six months of the year of investigation was about .40. During the last part of July it increased rapidly, and during August the average color was .64, varying on different days and reaching as high a point as .86. During September the average color was .57, and during the remaining months of the year about half of this.

There were eight filters receiving this water, the principal ones being known as Filter A-B, Filter C, and Filter G. These filters each contained five feet in depth of sand of an effective size of 0.28 millimeter, and with a uniformity coefficient of 3.2. Filter A-B was operated at a rate slightly greater than 2 500 000 gallons per acre daily, Filter C at a rate of 5 000 000 gallons per acre daily, and Filter G received the effluent of Filter A-B at a rate of 10 000 000 gallons per acre daily.

Filter A-B, operating at a $2\frac{1}{2}$ million rate, removed during the first three months of the year, when the water in the reservoir had an average color of .41, 17 per cent. of this color; during April, May, and June its efficiency increased and it removed 32 per cent.; during July, August, and September, when the color of the reservoir water was high, it removed 63 per cent.; and during the remainder of the year 40 per cent. That is, during the four months of the year when the reservoir water had the highest color, the effluent of this filter averaged as low or lower in color than during the months of the year when the reservoir water had the least color. The result was due to a number of causes: The increased temperature enlivened bacterial oxidation in the filter, which caused a considerable increase in color removal; the color removal was large also because of the nature of the coloring matter in the reservoir water, which was absorbed from the decaying organic matter during the period of fermentation, so to speak, in the reservoir: that is, a

combination of high temperature, scarcity of free oxygen in the water, and undoubtedly its entire absence in some places, together with a bacterial activity which rendered this organic coloring matter easily oxidized in the filters, all helped in giving good color removal.

The filter receiving the water at a rate of 5 000 000 gallons per acre daily removed nearly as high a percentage of coloring matter as the one just described, operating at half that rate.

Filter G, receiving the effluent of Filter A-B and operating at a rate of 10 000 000 gallons per acre daily, removed about 30 per cent. of the color of the applied water: that is, during the five months of the year when the color of the reservoir water was highest, averaging during two of these months .64 and .57, and during many days and weeks of this period being even higher in color, the color removal by sand filtration at rates of 2 500 000 and 5 000 000 gallons per acre daily was 63 per cent. and by double filtration 75 per cent., giving a final effluent with a color of .13.

Filters of the same construction as these already described were operated with the water of the canal which enters the reservoir. This water, although largely from swampy sources, apparently contained organic matter in a more stable condition than that in the reservoir water. During several months of the year, however, approximately 50 per cent. of the coloring matter of this water was removed by the filters: that is to say, sand filtration, unaided by chemicals, both at Lawrence and at Springfield, removed approximately 75 per cent. of the coloring matter from highly colored waters when this organic coloring matter was taken from decaying vegetable matter and when it was in a state of unstable equilibrium, so to speak. With the organic matter in water in a more stable condition, however, as is the case in the Merrimac River water when it is the most highly colored, only from 20 to 35 per cent. of the coloring matter can be removed by sand filtration.

REMOVAL OF ODOR.

The odors of the waters which we have experimented with have been caused either by the absorption of the characteristic odor of growing vegetation, or by the decay of vegetation, or have been imparted to the water by the life and death of microscopic organisms. The odors present in the Merrimac River, which is at the present time badly polluted by domestic and manufactural sewage, are easily removed by sand filters when operated at a very high rate. The

filters operated at Lawrence during the past three years, receiving water treated with vegetable matter in order to increase its color, etc., have almost universally removed all the odors, often strong, imparted to this water by the decaying matter which we have placed in it.

In the Lawrence experiments we undertook to cause the growth of organisms in our colored water supply tank, but the only one which appeared there in any numbers, and which causes odors in water, was *asterionella*. The odor caused by this organism appeared to be quite prominent at times in this water, and the filters invariably removed a very large percentage of it. Ludlow Reservoir water, however, is one which at times, for many years, has caused serious trouble to its consumers because of the growth within it of *anabæna*, *uroglæna*, etc., and this was the case during a considerable portion of the period of investigation at Ludlow.

We made daily microscopical examinations of this water from the beginning of February, 1901, until the end of January, 1902, and the water passed through many phases of microscopical growths in this period. During February the numbers of organisms present upon different days varied from 200 to nearly 900 per cubic centimeter, and *dinobryon* was present in considerable numbers. During March the daily number of organisms varied from 436 to 3 700 per cubic centimeter, being about equally divided between *asterionella*, *dinobryon*, and *zoöspores*. During April the number of organisms was considerably less, the highest number present being 656 per cubic centimeter, the larger number of these being *asterionella*. During the first part of May the condition of the water was about the same in this respect as during April, but beginning May 13 the number of *asterionella* present began to increase very rapidly, and large numbers were found from that date until June 18, the greatest number being found during the last week of May, when nearly 8 000 *asterionella* per cubic centimeter were present. During this month *synura* and *uroglæna* were also found several times. From the last part of June until the middle of July but few organisms were present in the water, but beginning July 12 *anabæna* began to be found, and it increased rapidly in numbers until it reached a maximum of 5 600 per cubic centimeter upon August 7, very few other organisms being found at this time except a few *asterionella*. From August 8 until August 16 *anabæna* was only once found in numbers greater than 2 000 per cubic centimeter, but beginning on the latter date

there was a period of a few days when much larger numbers were present, the greatest number on any day being about 11 000 per cubic centimeter. From this time it was uniformly present in the water in comparatively large numbers until the middle of September, when it grew rapidly less, and practically disappeared from the reservoir by September 25.

The odor of the reservoir water followed to a large extent its microscopic condition. During the first part of 1901 the odor was only very faint, and was designated as vegetable. Through the last part of February and lasting until about the first week in April, the odor of dinobryon was noted frequently in the water, and during April and a portion of May the aromatic odor due to *asterionella* was detected, especially when the water was heated. During June the odor of the water was designated as either fishy or aromatic when cold, and decidedly grassy when heated. At the beginning of July the grassy odor due to *anabaena* began to be very prominent, and this odor increased very materially, until the water had an exceedingly strong, disagreeable, grassy odor, due to *anabaena*, both when cold and when heated, and this condition lasted for two months, that is, until the 24th of September, the strongest odors occurring from about the 20th of July until the end of August. During this period the odor, not only of the water but at times of the air around the experiment station, was very strong, and the growth of *anabaena* in the reservoir formed a thick layer along one shore, reaching out 40 or 50 feet into the water.

Filter A-B and Filter C, receiving this reservoir water at the rates of 2 500 000 and 5 000 000 gallons per acre per day, as already stated, removed practically all the odor of the applied water until the middle of July; that is to say, none of the fishy odors that might have been expected owing to the presence of large numbers of dinobryon in the reservoir water, and only a very slight trace of the aromatic odor due to *asterionella* in the reservoir water, were noted during the early months of experiment. During the period when *anabaena* was present in the water, however, and the water had a very strong odor on this account, this odor persisted in the water during its passage through the filter, and was present in the effluent of each of these filters, but to a considerably less degree than in the reservoir water. Filter G, however, to which the effluent of Filter A-B was applied at a rate of 10 000 000 gallons per acre per day, was operated throughout this period of strong odors and pro-

duced an effluent entirely odorless, except at times when just collected from the outlet pipe of the filter; the odor at that time being so faint that its character could not be determined easily, and not having at all the odor of the anabaena in the applied water.

Filter C removed all organisms from the reservoir water, although Filter A-B for several weeks, beginning August 21, allowed anabaena to pass through; this evidently being due to some untoward disturbance of the surface sand of the filter.

The effluent of Filter G, receiving the effluent of Filter A-B, was free from organisms throughout its period of operation. By double filtration of Ludlow Reservoir water, even when containing an enormous number of organisms which produce odors, and having the characteristic odor of these organisms to an exceedingly marked degree, we removed not only all the organisms, but all the odors produced by them; that is, practically all odors caused by the enormous growths of asterionella and dinobryon in the reservoir water were removed by single filtration, and by double filtration all odors due to an enormous growth of anabaena were removed.

During the present year I have had a slight experience with filtration of a water containing large numbers of uroglena, and I am confident that this odor, even when very marked, can also be removed by sand filtration.

The water in the canal entering Ludlow Reservoir during this period had a very much smaller number of organisms than did the reservoir water, the odor of the water was very much less marked, and the filters receiving this water removed practically all the odor of the applied water.

DUTIES OF MUNICIPALITIES REGARDING WATER SUPPLY.

BY HON. J. O. HALL, QUINCY, MASS.

[Read September 10, 1902.]

Members and Friends of the New England Water Works Association, — It may seem presuming in one who has had no opportunity to deal directly with the real problems and difficulties which attend the business of securing water for and distributing it to a community to present a paper for the consideration of a body of men so practical and experienced as this, and I assure you I approach the duty with a great deal of trepidation.

The ability to secure an adequate and proper supply of pure water at the lowest possible cost to a community exists only in those of broad and varied attainments, ripened by extended and careful study.

The source of supply having been secured, much tact and constant watchfulness are required to protect it, that its purity may not be contaminated.

To properly and economically distribute the supply throughout the community is another and a separate problem, and to so forecast and plan this system of distribution that it shall meet the ever-increasing needs of the community with the minimum of cost for the substitution of larger waterways for those at first provided requires abilities of no mean order.

To watch the finances of such a system of supply and consumption, so that the management and construction may be economical and efficient, and the revenue religiously and satisfactorily collected, requires faithful and conscientious service not exceeded by any department of the public business.

In view of the ability required for the efficient care and administration of a system of water supply, which ability is so strongly shown by the members of this Association, do you wonder that I hesitate in offering a paper for your consideration?

There are, however, so many sides to the purposes and projects, to the duties and responsibilities of this special department of the

public service, that possibly I may be able to add something of interest or profit to the exercises of the passing hour. In a certain sense I may stand in the attitude of a theorist, not having been engaged intimately in handling the duties and difficulties which daily confront you, but the relations between the theorist and the practicalist may be strongly marked and yet both may exist in one person. There is the speculative theorist who is forever at work upon problems of research either in science or in sociology, and who is continually striking out the sparks which kindle in the brain of the practicalist those fires which give great results for the welfare and for the advancement of the human family. The theorist dwells in a different atmosphere from and is often the object of the strongest disapproval of the practicalist, yet both are needed and both have been equally the benefactors of the race.

The practicalist reaches the accomplishment of his purpose by feeling his way along step by step in action, while the practical theorist goes straight to his point by a way well thought out from the beginning, and by methods previously provided overcomes the difficulties which have been seen from that beginning.

Of all the many and varied lines involved in ministering to the needs and to the welfare of a community, none exceeds in importance that of furnishing an ample supply of pure water, and none demands more strongly the attention of the practical theorist. It may be claimed that water is a dry subject, but I do not think it so. We hear all sorts of ridicule regarding its value and uses, and its unpopularity except for the purposes of the toilet and the laundry, and many maintain that a little of it mixed with something of a stronger nature is the only reason for its existence. Notwithstanding all this, however, a water supply has been from time immemorial a subject for thought and careful preparation.

The patriarch built his well and carefully guarded its treasures and its surroundings, allowing only his family or his tribe or some favored ones, for generation after generation, to partake of its waters. His well was an important part of his wealth, for much, if not all, of his prosperity depended upon it; and if such a well proved to be of considerable importance, by reason of the quantity or quality of the water, it bore his name for centuries. As families and tribes grew to cities and nations, the well gave place to aqueducts, and the springs and rivers of the mountains were brought to the dwellers in the deserts.

As there is nothing new under the sun, so do we find to-day the well giving place to the pond and the lake, the pump giving place to the faucet in the sink, and the vast and beautiful Metropolitan Water System of to-day supplying our needy ones with this essential element for the health and happiness of mankind.

The governments of communities find that they stand in a somewhat different position in the business of furnishing water to the citizens than they do in the details of other public utilities.

A city or town must keep its streets safe for travel and its ways in condition to allow its citizens to pass day or night without harm. Consequently it may even be considered to be bound by law to light its ways and roads. It is held that a community is not obliged by law to furnish its citizens with water, and therefore cannot claim to be acting in the discharge of a public function in thus supplying said inhabitants, but must stand in the light of a party engaged in selling the commodity. Consequently we do not tax for this as in other items of community expense.

For this reason, doubtless, many communities have hesitated about contracting liability for such a supply, and individuals have thus been inclined to see a profit in considering this an article of merchandise.

I believe that the field for the exercise of public utilities should be confined to the smallest possible limits. While it may not be possible to enumerate such things as municipal governments should consider as being within their province, and to say that no others should be added to the list, I am firmly of the opinion that the number of the activities of our communities, into which the governments should enter as participants, should be kept at the lowest limit, and that any attempt to enter new fields should be permitted only after the most careful and rigid examination.

I conscientiously believe, however, that the supplying of its citizens with an ample supply of pure water is a proper exercise of the governmental prerogative, and is a duty which should be promptly and willingly rendered.

I believe it to be the province and the duty of the government to give all of its citizens the benefits of this supply, regardless of the item of a fair return of profit on the expense of the individual supply requested.

Aside from the convenience to the individual, the health and increased happiness of the citizens far outweigh the added cost to

the community. The supply should be all that it is possible to give, and it should be placed wherever it is desired.

So strongly is this opinion gaining in the minds of men that the governments of states are taking upon themselves the duty of providing this supply, and calling into service the best talent to be obtained to see that this supply is brought to its highest state of purity. This condition is brought about partly by the fact that an adequate source of supply may not exist within the borders of a community or in a group of communities, and partly because the community or group of communities may be unable to bear the heavy expense themselves, and the larger resources of the commonwealth must be called upon to meet the larger need.

I am firmly convinced that this is an advance along the proper lines. I do not believe that the use of water should be restricted, either for domestic use or in yard or street, but that an ample supply should be provided and its use encouraged.

Water is an educator, and its abundance encourages a more general use. Cleanliness is next to godliness, we are told, and while bodily purity is conducive to good morals, fresh, clean towns or cities with green lawns and bright flowers and shrubbery are beautiful and restful to the eye; they are equally conducive to the happiness of all,—the poor and ignorant alike with the wealthy and cultivated,—and are sure to advance all to higher moral and intellectual conditions.

If communities were called upon to furnish a water supply simply for the domestic uses of their inhabitants the duty would be quite simple, or at least much simpler than it is under the present conditions, for aside from this demand of the households there must actually be a provision for the extinguishment of conflagrations and almost every community is called upon to make provision for a considerable supply for business or manufacturing purposes. So extensive is the consumption of water becoming, and so large is the quantity required, that I believe the use of water as the motive power in manufactures should be discontinued, excepting, of course, power received from flowing streams.

For fire protection the community must provide. The demand upon the water supply for the extinguishment of fires is periodic and, except in large cities, is not very heavy. The burden of expense in this regard is in the provision for distribution and providing a sufficient force to the stream to make it of value in the service.

The matter of the apportionment of the expense of constructing, maintaining, and operating a system of water supply is a perplexing one, requiring careful thought, and for which no general rule or system can be laid down, as the nature and conditions vary so widely in different locations. For water for domestic and household uses I believe the charge to the taker should be made as light as possible.

Believing as I do that it is the duty of the municipality to provide its citizens with a generous supply of pure water for domestic uses, I hold that that supply should be carried wherever it is wanted without considering the return which should come to the water plant in the revenue to be received. For irrigation of grounds a charge should be made in accordance with the amount which each householder desires to use, but he should be allowed to use what he wishes, paying therefor a fairly estimated cost of the service. For fire purposes the greater portion of the expense should go directly into the tax rate of the city or town, and should not apply at all to the water supply. As I have stated, the great expense is in the provision for distribution and for a sufficient head, and as regards the provision for distribution, all expense concerned in connecting with the main line of pipes and setting of hydrants should be a charge to the fire department and should be included in the items for which the tax provides. All expense for care and maintenance of hydrants should be chargeable to the fire department.

I am supposing that the municipality is furnishing the water in what I have said here. If a private company is furnishing the water and establishing and maintaining the entire system, the charge is to the municipal government, and the proper distribution of that expense to its several departments is the duty of the municipal government. If the municipal government is establishing and maintaining its own system of distribution, the private company furnishing the water simply, then my first method prevails.

Because of the limitation by the statutes of the amounts which cities and towns may raise by taxation, there is a constantly increasing practice among appropriating bodies to divert receipts from their proper purpose and to throw burdens of expense upon departments other than those to which they are properly chargeable.

Allow me to say in passing that this legislation is not accomplishing the purpose which was sought for, namely, the prevention of excessive and unwise appropriations by municipal governments, but

is a constant source of temptation to juggle with the appropriations, and after the limit has been reached, after every possible interpretation in appropriations to avoid the law, a resort is made to borrowing on extended time.

I believe that all limitations should be removed from the statutes regarding municipal indebtedness, and communities be permitted to appropriate whatever they wish to be taxed for, and the large burden of debt and interest would be taken from the hands of the taxpayers. The citizens would then take care of themselves, for they would immediately feel the pressure of unwise or needless extravagance and at once apply the needed remedy.

On the question whether or not the public buildings and the fire department should return a revenue to the water system there are differing opinions, and while there are some reasons why it might seem to be the only fair way, I am of the opinion that this claim to revenue should not be too strongly dwelt upon. A provision for this revenue would result in increasing the expense of government, thereby accumulating a revenue which would be used in additional expenditure. Charging the fire and municipal departments for water used would necessitate increased appropriations for these departments and would furnish an accumulation of money which would be an incentive for extra expenditure, which in the majority of cases would be unnecessary and consequently unwise.

It is impossible with our finite limitations to do exact justice to any system, and the comparatively small item of revenue from these sources, if demanded, would, it seems to me, work more injury to the citizens than the benefit to the water system would compensate for.

If we separate the domestic demand from that for business or manufacturing purposes, we are rid of the item of water stealing to a very large extent. For the latter demand the water meter should most certainly be used, and a separate supply for business uses entirely beyond the control of the party using it should be provided. For this metered service the charge should include every item of cost to which the community has been put in order to bring the supply to the doors of the business demanding it. If it is claimed that as citizens of the community they are entitled to water privileges, the demand should be met by providing for them a supply entirely independent of the business supply.

With the meter service, a thorough water inspection, and the

business demand separated, the amount of water stealing will be reduced to the minimum.

As to the question whether water should be supplied by the communities themselves or by private individuals or companies, I think what I have said up to this time substantially answers that question. If it is the duty of the community to provide water for its citizens, then the individual, either native or foreign, has no opportunity or inducement to enter the field.

Wherever there is a large aggregation of people who are not permanent residents but always temporary and constantly changing, there may be a field for private enterprise and capital. Indeed it is a subject for inquiry whether a government of a community would have the legal right to loan the government credit for an enterprise which should be almost entirely for a foreign citizenship and which might furnish a temptation and an opportunity for private aggrandizement.

For the permanent citizenship I believe it to be the duty of the community to provide the water needed for the life of that community. The fields into which municipal governments should enter are to my mind, as I have said, few, but I believe the supplying of water to be eminently the proper function of government.

So far as the cost to the citizen is concerned, it will be larger in the total under municipal management than under that of a private individual or company, but he will get more for his money and a more extended service, whether it be a water service or a lighting service. This must be the case, for under municipal control he has a voice, through his representative in the appropriating body, in the control of the business, whereas in the case of the private company he has no claim.

In order that the citizen shall have his water supplied at the lowest possible cost, the duty is laid upon the officials of the water department to make such accounting of their administration as shall show in the most complete manner the finances of the several heads of construction, extension, maintenance, operation, and control. The incidental and preliminary cost of examination for a water supply, with the consequent legislation, is an item by itself. The construction of dam, reservoir, pumping station, and standpipe should constitute another item, the several individual parts showing in detail, and the sum total showing the cost of that part of the plant. The lines of distribution throughout the community comprise another item,

and this should show in detail main lines, house connections, and hydrant connections. this latter item to be returned to the water department from the fire department.

Your service is now ready for business, and the sum total of the several items shows the cost of the plant and constitutes the water debt. To this will be added year by year a further sum for extending the system, and your annual reports should show the entire cost of the plant to the close of each year, the reduction of the debt which has matured up to the close of the year showing the net water debt.

In the operation of the plant it is hardly possible to state a line of accounting, because of the great difference in conditions in the different communities. Uniformity of accounts in the several cities and towns is wellnigh impossible, and even similarity of accounts will be found extremely difficult to arrange and maintain. Differences of charters, methods of appropriation entirely dissimilar, constitutions of governing bodies continually varying, — all these conditions combine to make the labor of one superintendent totally unlike that of any other. Differences of construction in machinery, made necessary by differing local conditions of supply and of topography, and the too frequent changes in the officials in charge of this department, still further complicate matters and augment the difficulties.

An effort to obtain uniformity of city charters is not very successful, and I think charters will always differ quite materially, for the reason that citizens of different communities differ in opinions, and the conditions and demands differ in each case.

Systems of management and of accounting will always differ, because no two men are likely to adopt the same method for the solution of difficult problems, and no two communities will be willing to adopt just the same methods for conducting their community affairs. Hence systems of accounting and methods of operation must be instructive by inference rather than by actual similarity for comparison, except in very few cases. A knowledge of the meaning of facts and figures is the power that makes tables and statistics of value. All can make figures, keep accounts, and compile statistics; not all can read their meaning.

As the blood goes pulsing from the heart to the very smallest artery in the farthest extremity of the body, refreshing, feeding, and invigorating every atom of the bodily construction, and passes back through small and larger veins to the fountain reservoir to be

sent again on its life-giving mission, so the water expense goes out in plant and the vast and varied system of distribution through public building, fire protection, and the multitude of domestic demands, only to come flowing back into the treasury in the form of revenue, to be sent out again over its course of universal comfort, convenience, and blessing.

The ceaseless round of nature and of the life of men is ever repeating itself. Seedtime and harvest never fail; men sleep and rise refreshed only to grow again weary. All the work of nature is to return again and again in a never-ending round. So communities gather from their citizens moneys to be returned to them in general benefits.

But, gentlemen, I must not weary you longer. The work in which we are engaged is full of difficulties, and many are its discouragements. In moments of enthusiasm we see the possibilities, but in the practical everyday work of life the clouds sweep over the scene, and only an occasional glimpse of what might be is all that is left to keep the soul alive; but when forms of government and systems of water works shall have passed away the soul of man that has worked its problems for the love of humanity and for the uplift of its power, that has been refreshed after the troublesome problems by visions of waste places made to blossom as the rose, shall find its rich reward and pass onward from the limitations of time into the infinite possibilities of eternity.

DISCUSSION.

PRESIDENT MERRILL. We are indebted to Mr. Hall for his interesting and valuable paper, and it is now before the convention for any remarks which any gentleman present may wish to offer.

MR. FREEMAN C. COFFIN.* The paper which we have just heard is certainly a very suggestive one, and there are some points in it which particularly appeal to me. The speaker noted that it was desirable that the use of water should be abundant. I think that we probably all agree with him in that, but many people seem to confound an *abundant use* of water with the *unlimited waste* of it. It is certainly desirable to furnish all the water which is actually needed for use in any legitimate direction, but there is a great waste of water, and the difference between the use and the waste should be emphasized, and the fact that there is a difference not lost sight of. Without

* Civil Engineer, Boston, Mass.

going into details in relation to the waste of water, it is probably safe to say that in many cases the amount of water wasted is a very large percentage of the whole amount of water supplied in a town, even in certain cases exceeding the legitimate use of water; and while it is desirable to furnish an abundant supply, it is fully as desirable at all times to take every measure which can be taken to restrict the waste.

I speak of this at this time because there is so much said, not among those who are acquainted with this subject, but in the papers and in discussion of the subject by others, in opposition to the use of meters. Now, while it is not always desirable to use meters, still it seems to me that there is no real objection to their use, except, perhaps, under certain local conditions, where it may not pay to use them, or something of that kind. The use of meters certainly will not prevent the abundant use of water, under the ordinary rules and conditions governing them.

The gentleman spoke of the apportionment of the expense of the system for different services, and I should like to say a word on that subject. There seem to be two distinct forms of service in a water system. One is the domestic service, including the supply for manufacturing purposes, and the other is the service for extinguishing fires. As he well said, constructing a water system so as to make it suitable and efficient for fire protection increases the cost over what it would be if it were simply for domestic purposes. From the study I have been able to make of it I have arrived at the opinion that if there were to be a just apportionment of the expense, it would not be very far out of the way if the fire service were charged one half and the domestic service charged one half of the total annual expense; that is to say, the difference between constructing the system for fire protection and for domestic service combined would be about as much in excess over a purely domestic service as the combined system would be over a fire service, taking it in a rough-and-ready computation. Of course, local conditions would affect that. The tendency seems to be in municipal works to have all of the expenses finally charged to the consumer, that is, to have the revenue from consumers meet the whole annual expenditure for the service. It seems to be generally considered that that is a good business practice, but to my mind it is a question whether it is or not. It may be wise in some cases, but whether it is desirable and just to charge the consumer, who is not necessarily or not always identi-

deal with the taxpayer, a certain sum of money which the taxpayer should pay as an offset to the benefits he receives from fire protection, I do not feel sure.

There is one point I should like to speak of, something I have run across a great many times, and that is the practice of selling water for motors, for purposes of power, at a merely nominal figure. In my opinion it is wrong to sell water for such purposes at a less figure than it costs to supply it, but this is done in a great many cases.

Speaking of uniformity of accounts, I suppose what the speaker said is true, but it does seem desirable that there should be a certain uniformity in the way of statistics. This Association, it seems to me, has made a good beginning in that direction, and it would be very desirable if all the works could report in conformity with our form of statistics, thus enabling those who desire to obtain knowledge and information in regard to these matters to compare one works with another, or with some standard which they may have.

THE PRESIDENT. Perhaps Mr. Baker can give us something of interest in regard to that portion of Mr. Hall's address regarding the difficulty of obtaining uniformity in municipal accounts.

MR. M. N. BAKER.* Mr. President, I don't know that I wish to take up any very great amount of time just now with that phase of the subject, but I can say that while I appreciate most fully the difficulties involved as outlined in the paper, yet I consider them by no means insurmountable; and the matter of uniformity of accounts and statistics is so very important that I think every attempt should be made to improve upon the present chaotic condition, a condition existing not merely as regards a comparison of one city with another, but even of the accounts of a water department year by year in the same city. I think we all have reason to be very grateful for the progress that is being made and the interest that is being shown in the movement for uniform accounts and statistics, not only in the water-works departments, but in other departments of municipal governments.

I should like to say a word on the apportionment of the cost of the service between private and public consumers. There is not the need of so much to be said before an assembly of water-works men upon this subject that there is of addressing ourselves to the newspaper editors, the politicians, and the general public. There is a

* Associate Editor, *Engineering News*.

continual clamor for reduction of rates to domestic consumers, but of course such reduction cannot be carried to any great length without putting the burden upon the general public. If the burden is to be put upon the general public at all, why not charge the public for the water it is using, and thus get at the problem in a scientific way?

THE PHYSICAL PROPERTIES OF WATER.

BY ALLEN HAZEN, CIVIL ENGINEER, NEW YORK, N. Y.

[Read September 11, 1902.]

The physical properties of water, about which I shall speak to you to-day, are those which relate to its appearance, and which have their origin in the foreign matters which it contains.

The rivers of New England impress one from the West as being of surprising clearness. The stones over which the water flows are clearly seen, and the brilliant transparency is a source of constant pleasure to one accustomed to more turbid waters. In the same way, and for the same reason, the public water supplies of the New England cities have been more attractive in appearance than those of many other parts of the country, and perhaps we have felt a complacency in seeing the efforts of our Western neighbors to secure waters equal in appearance to those which come to us almost without effort.

But as the world develops conditions change. Instead of pitying those who have to use turbid waters in less favored conditions, New England must now make a determined effort to keep the appearance of her public water supplies even equal to those of the Middle States.

The matter has come about in this way: The waters of the Mississippi Valley and elsewhere were discolored by clay and other extremely divided matter washed from the soil, and carried in suspension by the water. The material so carried is what is known as turbidity.

In the smallest amounts these matters make the water look as if it had milk in it; with larger amounts, the water appears muddy, and finally almost like mud. The color of such waters, as it is commonly called, depends upon the color of the particles comprising the turbidity. Gray is most common, but black and red are not uncommon. The New England waters are, in general, free from this kind of material. The river and lake and pond waters, on the other hand, contain a yellow coloring matter which has been extracted from dead leaves and other vegetable matter with which they have been in contact. This coloring matter is similar to, or possibly iden-

tical with, the coloring matter of tea, and waters carrying it have the appearance of weak tea. Some New England surface waters have more of this matter than others. In some it is hardly perceptible, but it is present in nearly all of them. The term "color" can be applied, properly, only to this kind of coloring matter, and should not be used to include the color which arises from a colored turbidity.

Turbidity may be said to be a stronger property of water than color, because it is more conspicuous, and because it covers color and renders it unimportant; this is to say, if a colored water is made turbid by adding clay to it, it becomes simply a turbid water. The color no longer shows, and, in fact, if the turbidity is removed by filtration or otherwise, it will usually be found that the color has been removed also. This is because the clay particles seem to have an affinity for the color, and probably enter into some loose chemical combination with it. Of course a slight turbidity does not serve to cover a heavy color; but, generally speaking, with both present the turbidity controls and the color ceases to be important.

As turbidity is the stronger property, it is commonly regarded as the more objectionable in a public water supply; and so it has happened that the cities having turbid waters have made the most strenuous efforts to improve them. It is true that the purification of water has been directed in part to the removal of the disease-producing properties which are so common in river waters, but the appearance has also been, always, or nearly always, an important consideration. Most people will say that to render a water hygienically wholesome is more important than to remove the turbidity; but, notwithstanding this, up to the present time I believe that the desire for clear water has been a more important factor in securing water purification than the desire for wholesome water. It is like the old case of the man who first consults his lawyer about his property; afterward, his doctor about his body, and finally, if there is time left, his clergyman about his soul. The matter which is seemingly least important receives first and most serious consideration. It has been much the same with water. Many of the cities using turbid waters have introduced the settling basins and coagulants and filters, or as many of them as necessary, and have removed the turbidity; and with the turbidity, the color, if present, has usually disappeared or has been reduced to an unimportant amount.

The cities still using such waters raw are all considering the question of purification, and within the last five years the question itself has changed. It is no longer, "Shall we filter our water?" It has become instead, "How shall we filter it? What means are to be adopted? And how shall we raise the money to pay for it?" The time is not distant when the cities that were and are supplied with turbid water will be supplied with clear and generally, also, with colorless, or nearly colorless, water.

The yellow waters of New England were far more attractive in appearance than the turbid waters of the West; but equally, the turbid Western waters are far more attractive in appearance after they have been filtered than the yellow New England waters. And so it happens that if New England is to hold her relative position, the question of the physical properties must be squarely and adequately met, and means of controlling and reducing the color must be found and applied.

It is not my purpose to describe to you to-day the methods which have been proposed and used for doing this. I wish rather to interest you in some preliminary work which is necessary to a full understanding of the question. Full and accurate knowledge of the present conditions is the best foundation on which to project plans for the improvement of those conditions; and I wish to-day to interest you in securing and keeping full daily information as to the colors and turbidities of the waters under your charge. I know that very much has already been done in this direction, particularly in Massachusetts, by the State Board of Health, the city of Boston, the Metropolitan Water Board, and others, but even in New England there is sometimes room for improvement.

The United States Geological Survey has taken the matter up. At the request of Mr. F. H. Newell, hydrographer of the Survey, I undertook last year to design apparatus for measuring the colors and turbidities of waters for the Survey. The apparatus had to be thoroughly portable, and so simple that it could not get out of adjustment. It was necessary that it should be thoroughly accurate under all conditions, and reliable even in the hands of comparatively inexperienced operators. Sets of such apparatus were designed and made for the use of the hydrographers of the Survey, and with the consent of Mr. Newell, arrangements have been made to place the apparatus on sale, by the parties who have made it. In designing the apparatus, the methods in common and approved use have been

followed, with only such slight modifications as seemed necessary or desirable.

For the color, the platinum-cobalt standard is used. Comparisons are made in aluminum tubes with glass ends, with side openings for rapid filling and emptying, as shown in Fig. 1. The standard length of tube is 200 millimeters, but shorter tubes are provided for waters with very high colors. The standard solution of platinum, because of its acidity, is difficult and dangerous to carry about; and, further, in inexperienced hands, may not be properly kept and diluted, and so the standards made from it may not have the supposed values. This is

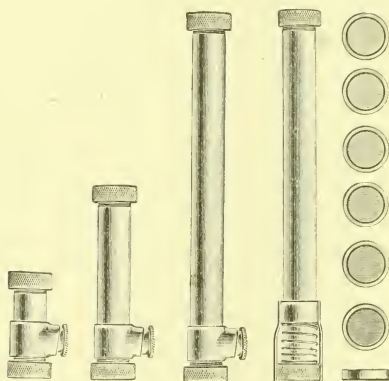


FIG. 1. — TUBES AND COLORED GLASS DISKS FOR MEASURING THE COLOR OF WATER.

met in the new apparatus by substituting glass slips of known values. Glass was found having color like the color of an average water and also like the color of the standard platinum-cobalt solution. This glass is cut into disks of various thicknesses, corresponding to the desired colors. These disks are mounted in aluminum and stamped with serial numbers for the purpose of subsequent identification. They are then compared directly with standard platinum-cobalt solution, in apparatus designed for that purpose, and the value of each disc determined. This value is then stamped upon the aluminum mounting, the figure representing the parts per million of metallic platinum which would produce an equal color when seen in a stand-

ard tube 200 millimeters long. These disks are placed singly or two at a time, as may be required, behind an empty tube, which is provided with a catch to hold them in place, and when the slip or slips so held appear equal in color to the water in another tube, held beside the one with the disks, the color of the water is the amount stamped on the disk, or the sum of the amounts, if there are two or more of them. It will be seen that this is not a new color standard, but a new method of applying an old standard. It is like the use of an aneroid in place of a mercurial barometer. The results are the same, while the method of application is so simplified as to make a very much more general use of the standard possible.

For measuring turbidity the stick method was adopted, but with a new graduation of the scale, in accordance with the recommendations of the committee of the American Public Health Association worked out in detail and defined by Mr. G. C. Whipple and the author. In principle it depends upon the distance beneath the surface of the water at which a platinum wire one millimeter in diameter can just be seen, the light being full and strong, but not direct sunlight. When the wire can be seen 100 millimeters, the turbidity is 100, and corresponds, as nearly as can be determined from available experimental results, to 100 parts per million of silica in suspension on the silica standard proposed a few years ago by Mr. Whipple. The graduation above and below has been computed from many experimental results with different waters, so that when a turbid water is diluted with a clear one, the turbidity as read will always be proportional to the amount of the turbid water in the mixture; in other words, the figures represent parts per million of suspended matters, except that equal amounts of material of different degrees of fineness produce different degrees of turbidity, and for definiteness a certain arbitrary degree of fineness is selected. This degree of fineness is such that the wire can be seen through 100 millimeters of water containing 100 parts of the material. The computation of the other points on the scale is approximate. Probably the exact graduations would differ somewhat for different kinds of turbidity-producing matter. The values were selected and arranged from the best existing data, and, if necessary, it is proposed to revise the scale when more extended data are obtained, retaining the 100-millimeter mark as the basis.

In using the stick the eye is always supposed to be 1.2 meters, or about four feet, from the wire. A straight stick somewhat longer

than this, say four and one half feet long, should be used for continued observations at one point. This is not convenient for a portable stick, and a pocket arrangement has been devised. It consists of a short aluminum bar, with a platinum wire and the beginning of the graduation. The rest of the graduation is on a tape containing bronze wires to prevent stretching, and attached so that when not in use it folds around the aluminum bar, as shown in Fig. 2. To hold it stiff in running water a catch serves to hold it to any rough stick which can be picked up upon the ground. Near-sighted people, and some others, cannot make the observation

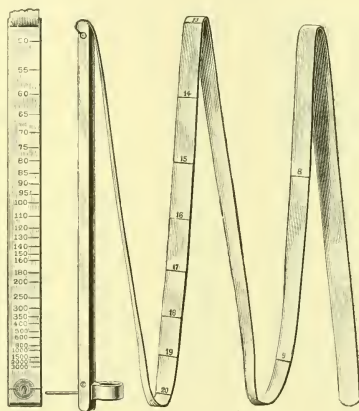


FIG. 2. — POCKET TURBIDITY STICK.

properly. It is, therefore, well for each person using the apparatus to compare his readings with those of several other people (experienced people, if possible), and to examine carefully the men that he uses for observers before placing full confidence in their results.

The whole apparatus for measuring both turbidity and color is so compact that it has been possible to put it in a case of pocket size, which will increase its convenience to many people.

The apparatus which I have described is intended to facilitate measurement of color and turbidity, and to make the results uniform and reliable. To get necessary and accurate records is an important

step, but it is only a step, and it should not be forgotten that the ultimate object is to improve the physical properties of our water supplies, which are only second in importance to their hygienic properties.

DISCUSSION.

MR. F. H. CRANDALL. I should like to ask Mr. Hazen if it is not necessary to use some precaution to prevent the sunlight affecting the glass?

MR. HAZEN. In our experience thus far, which only extends over about a year, we have seen no indication of change in the colors of the glass standards. If they should change, the glasses can be re-rated in the same way that they are rated at first.

MR. CRANDALL. You understand that they are fixed.

MR. HAZEN. So far as I know the colors are absolutely fixed. A glass will get scratched after a while in field use and will, no doubt, need to be replaced ultimately by a fresh one.

A MEMBER. I should like to ask if it is not necessary in determining turbidity that the surface of the water should be smooth, and whether it would not affect the reading if you were taking a reading on a running stream where there was a ripple on the water?

MR. HAZEN. It is always the rule to select a quiet place. In large rivers better results are secured by drawing the water in a bucket and then taking the turbidity immediately after drawing, and before settling has commenced to take place. In some cases the turbidity will be reduced 10 per cent. by waiting three or four minutes.

MR. ROBERT SPURR WESTON.* Perhaps it will be interesting to the members of the Association to give in this connection a brief summary of the experience in New Orleans during the investigation of the local water purification problem, when several thousands of turbidity determinations were made, both by the wire method, just described by Mr. Hazen, and also by the diaphanometer.

The diaphanometer used was similar to that used by Parmelee and Ellms at Cincinnati, and described elsewhere.† It consisted of a tube about one meter (40 inches) long and 30 millimeters (1.2 inches) in diameter. This tube was supported upon a box in which was placed the illuminating apparatus. At the lower end of this tube there was an object glass, the four quadrants of which were

*Sanitary Expert, Boston, Mass.

† *Technology Quarterly*, vol. xlii, pp. 157, 1899.

partially blackened in such a manner as to leave a transparent cross with arms one millimeter wide. This "cross-of-light" corresponds to the wire of the wire method, and the turbidity is determined by noting the vanishing point of this cross when the same is viewed against a strong light.

This cross was lighted from below by means of a Welsbach light, the rays of which first passed through a double plano-convex condenser and were reflected up through the tube from an inclined convex mirror. The condenser and convex mirror helped to destroy the image of the Welsbach mantel.

The instrument was used as follows: After the burner was lighted, water was poured in at a point near the top of the tube until the "cross-of-light" vanished from view.

The diaphanometer was standardized in a manner analogous to that employed by Messrs. Hazen and Whipple in standardizing the wire method. All results were expressed in terms of standard silica suspension, as determined from experiments made with the diaphanometer to determine the depths at which standard suspensions of silica would cause the "cross-of-light" to vanish. Thus, a water which had a turbidity of 100 caused the "cross-of-light" to vanish at the same point as a suspension containing 100 milligrams of silica to the liter.

For the purpose of comparison, turbidities were also determined by means of the wire method just described. This was done on a large number of samples, in order to determine the comparative values of the two methods.

The turbidities of many samples — those having turbidities of less than 40 parts per million — were determined by direct comparison with the silica standards in bottles or tubes. Waters having a turbidity of more than 500 parts per million were diluted with distilled water previous to the determination of the turbidity.

In general, the experiences at New Orleans went to show that determinations could be made more precisely with the diaphanometer than with the wire instrument, but that the latter was much more convenient. Furthermore, determinations could be made much more rapidly with the wire instrument.

The diaphanometer is especially useful in laboratories connected with rapid filter plants, where it is necessary to vary the amounts of applied coagulant according to the varying turbidity of the unfiltered water. As it is necessary to vary the amounts of coagulant

during the night time, the diaphanometer is very useful because it is independent of daylight, while the extremely neat and compact device just described may be used only during the hours of bright daylight, and is best used when instantaneous pictures could be taken with a camera. The wire instrument seems to be the best for general field work, and Mr. Hazen is to be thanked for having devised such a portable instrument.

At New Orleans it was found that single determinations made by the diaphanometer varied from time to time with different intensities of light, different observers and different suspensions of silica. The total variation reached 15 per cent. at times and the personal error of reading was as high as 7 per cent. among three or four observers.

The table on the following page shows the relation between the various methods for determination of turbidity, as practised at New Orleans. One column gives the equivalent values of the silica scale of the United States Geological Survey, which has just been described by one of its originators.*

It will be seen that there are some differences between the turbidity scale of the United States Geological Survey and that established at New Orleans, or, as Mr. Hazen has just expressed it, the values of the standard vanishing depth expressed in terms of silica differ. It was impracticable to exactly determine the reasons for this difference while the work was in progress. Possibly the differences may be charged to differences in the silica used as a standard of comparison.

Many of the determinations were checked by gravimetric determinations of suspended matter. When these were compared with the turbidity determination it was soon observed that when the Mississippi River partook largely of the character of its southwestern tributaries (the Red and Arkansas Rivers), a given amount of suspended matter would produce more turbidity from an optical standpoint than the same amount of suspended matter when the river water partook largely of the character of some of its other tributaries, — notably the Upper Mississippi. This phenomenon led to the adoption of the expression "turbidity coefficient," which is a measure of the character of the particles producing the turbidity, and is a ratio between the suspended matter determined gravimetri-

* Hazen and Whipple: Circular No. 8, U. S. Geological Survey, Division of Hydrography, 1902.

TABLE SHOWING THE RELATION BETWEEN THE VARIOUS METHODS OF TURBIDITY DETERMINATION.

<i>By Direct Comparison with Silica Stand- ards.</i>	<i>By Diaphanometer Expressed as Parts of Silica per Million.</i>	<i>Silica Scale of U. S. Geological Survey.*</i>	<i>Wire Reciprocal of Vanishing Depth in Inches.</i>
5	—	—	0.018
10	—	12	0.037
15	—	16	0.049
20	—	24	0.070
25	—	27	0.078
30	—	31	0.090
40	40	43	0.12
50	50	56	0.15
60	60	68	0.18
	70	81	0.21
	80	94	0.24
	90	108	0.27
	100	123	0.30
	120	149	0.35
	140	176	0.40
	160	198	0.44
	180	225	0.48
	200	246	0.52
	220	274	0.55
	240	296	0.58
	260	325	0.62
	280	355	0.66
	300	378	0.69
	320	403	0.72
	340	441	0.76
	360	471	0.79
	380	500	0.82
	400	542	0.86
	450	628	0.94
	500	720	1.02

The above are average determinations on samples from all sources, Mississippi River, river and settling basin effluents.

* Hazen and Whipple: Circular No. 8, Division of Hydrography, 1902.

cally and the turbidity expressed as the equivalent number of parts of silica per million. —

$$\text{Turbidity coefficient.} = \frac{\text{Suspended matter.}}{\text{Turbidity.}}$$

Waters containing coarse, crystalline silt particles, which have a low turbidity-producing power, have a high turbidity coefficient, while the opposite is true of waters containing finely divided clay particles.

While much data has not been collected as yet, it may be said that the turbidity coefficient of American streams varies roughly between 0.5 and 1.5.

MR. KENNETH ALLEN. In connection with the removal of color, Mr. Clark this morning spoke of removing from zero to 62 per cent., I think, by a single filtering through sand. It would be interesting if Mr. Hazen, or Mr. Clark if he is here, would tell us something about the effect of filtering with a coagulant by a rapid filter, and what experience has been had with rapid filtration and with a coagulant.

MR. H. W. CLARK. I think Mr. Hazen has had much more experience than I have had in the filtration of colored waters and the use of a coagulant, and I will refer that to him.

MR. HAZEN. I am sorry that Mr. Clark has not had more experience with coagulant—I have often suggested to him that he get it. [Laughter.] The color can be removed by the use of a coagulant, but it often takes a great deal of coagulant to do it. Something is known about the amount required for different waters, but it is dependent upon a whole series of conditions, and so cannot be computed by any simple formula. The amount of color is naturally the most important single condition which determines the necessary amount of coagulant, and, other things being equal, the amount of coagulant required is proportional to the amount of color; the amount of alkalinity affects it, and also the presence of other matters in the water. Generally speaking, it takes a good deal of coagulant to remove the color, and when colored waters are filtered by mechanical filters it often happens that coagulant is used only in such quantities as to remove a small percentage of the color, and the color removed is not greater than it is with sand filters. However, by the use of sufficient coagulant nearly all the color can be removed.

ECONOMY IN THE USE OF COAL FOR THE
PRODUCTION OF POWER.

BY PROF. IRA N. HOLLIS, HARVARD UNIVERSITY, CAMBRIDGE, MASS.

[Presented November 12, 1902.]

It is difficult to write anything new on economy in the use of fuel, especially before a society which is familiar with its uses. Many inventions have been tried of recent years with little gain of efficiency when compared with the vast amount of heat wasted in the chimney or in the exhaust of a steam engine. The rate of improvement has been a decreasing one, and, like the last knot in a 24-knot steamer, an enormous amount of human effort is required to produce a relatively small result. We seem to have reached a blind alley, out of which we can escape only by going back to try old ways long since given up or by striking out on some new path not yet indicated.

The fundamental motive at the base of all human invention is in the direction of saving labor, and thus of increasing the material comforts and leisure of the race. Broadly stated, this means that coal or water must do the work which men formerly did by hand; hence, for every ton of coal which we have been able to save by the increased efficiency of furnaces and machines, many tons have been added to the yearly expenditure by the enormously greater demand for power. We are already beginning to talk about how long the available supply of coal will last, and the late strike in the anthracite region has quickened interest in the subject, as it has given us a hint of what a coal famine would mean to a nation accustomed to depend upon it for work and heat. Yet we have hardly attacked the problem of economy in the use of coal.

A pound of good coal is capable of yielding from 14 000 to 15 000 heat units during combustion, equal, if all transmitted into work, to between 10 892 000 and 11 670 000 foot pounds. When used for heating purposes, as in reducing and blast furnaces, a very large percentage of this heat is lost at once; and when used in a boiler to drive a steam engine, a still larger percentage is lost, first in the boiler and next in the cylinders of the engine. Under the most

avorable conditions, we recover, in practice, only 1 320 000 foot pounds from each pound of coal, thus wasting more than 88 per cent. of its heat value. For every ton that is burned in a power house we throw away nearly seven and a half tons. This is only one example out of many, and as it is the one in which this society is most interested, it seems best to confine the present discussion to the use of coal in the production of power. Meantime, let us see what engineers are trying to accomplish.

The total possible saving in the steam boiler, which is given later, would be about 34 per cent. of the heat of the coal. This reckons the boiler efficiency at 66 per cent. Of the 34 per cent. referred to, we cannot hope to get back more than half, as fully 17 per cent. is required for draft, even when using an economizer. This leaves, as the maximum possible efficiency of a boiler, 83 per cent. In the case of the steam engine, the efficiency is governed by the thermodynamic law that the work is proportional to the range of heat. If we, therefore, take the upper temperature of steam at 900° absolute, and the lower at 600°, the ideal efficiency would be one third, or 33 $\frac{1}{3}$ per cent., which is rarely even approached. The highest mechanical efficiency that I have ever been able to find between the steam cylinder and the power to which it is applied is in the case of the Cambridge pumping engine, where the work done in the pump was slightly over 96 per cent. of the power developed in the cylinders. This would give us 96 per cent. efficiency. Multiplying the three efficiencies together, we have the maximum attainable efficiency under ideal conditions of 26 $\frac{1}{2}$ per cent.; that is, nearly three fourths of the heat of the coal must be thrown away, even under ideal conditions, for the working of a steam engine. We have been able, with the most economical of modern engines, to get one horse power on eleven pounds of steam, or even slightly less. This gives us about 12 per cent. efficiency. What we are working for, therefore, is the remaining 14 $\frac{1}{2}$ per cent., and we must remember that under no conditions is it practicable with the present materials for engines and boilers to gain more. Engineers may well strive to strike out on a new path. We are struggling with the steam turbine and with other inventions to save a few pounds of coal, while we are wasting tons.

One of the axioms of modern engineering is that the conditions most favorable to economy are the regular and constant demand for power. Where an engine is to be run at its designed maximum power for twenty-four hours a day, the entire plant can be made to

realize a much higher efficiency than would be the case with a fluctuating demand for work. Where this fluctuating demand prevails, the plant must be designed for the greatest output and yet used for long periods at much lower rates. This is like employing a man to do the work of a small child, because at times there are weights to be lifted that require a man's strength. Furthermore, paradoxical as it may seem, there are many cases in which economy would be obtained only at too great a cost; a good example of this being found in steam engines for small powers. It would not pay to build a one-horse-power engine with a steam jacket and condenser and air pump. The first cost would be too great, and the skill to render the design effective would be far beyond the ordinary rate of wages. The line of improvement in the use of small powers is clearly pointed out: a central station which can be kept working at a constant rate, and some efficient method of distribution to motors of such simplicity that cheap labor can be employed to run them. This may be called the problem of the twentieth century, inasmuch as there are many demands for small power to a comparatively few for power in large quantities.

Economy in the use of coal is thus divided under three heads:—

- (1) Efficiency in the recovery of heat after combustion.
- (2) Efficiency of the medium by which the heat is transmitted into work.
- (3) Efficiency of the machine which applies the work developed in the prime mover to a useful result.

When we consider that under these three elements of efficiency, exhaustive experiments, extending over a century, have enabled us to transmit under ordinary conditions less than 10 per cent. of the heat of the coal into useful work, we may realize the great field still open to engineers.

In a steam plant the boiler forms, naturally, the first element for study. Its efficiency is so much a question of the men who run it that we have arrived at no final type which may be expected to give the highest results. Any well-designed boiler will recover from the coal about 75 per cent. of its heat under the most favorable conditions. This falls to 40 per cent. and 50 per cent. with bad management, and it may rise to 85 per cent. with the addition of some device, usually separate from the boiler, for utilizing the waste heat. The following table, taken from a boiler trial reported in 1894 and republished in Bryan Donkin's book on "Heat Efficiency of Steam

Boilers," may serve a useful purpose in indicating the heat utilized and lost. The data were obtained from two Lancashire boilers and a Green economizer, and it is sufficiently near the average practice to serve as a type. A slight modification has enabled me to place all the data in one table.

	<i>British Thermal Units.</i>	<i>Per Cent.</i>
Heat transmitted to water in boiler	8 271	55.2
Heat transmitted to water in economizer.....	1 637	10.9
Heat lost in products of combustion.....	1 127	7.5
Heat lost in excess air.....	985	6.6
Heat lost in moisture from coal	23	.2
Heat lost in air leaking through brickwork of economizer.....	259	1.7
Heat lost in unburnt coal	342	2.3
Heat not accounted for, including radiation ..	2 342	15.6
Total	14 986	100.0

The third item in the table represents an unavoidable loss in one form or another. Combustion is produced by the contact of oxygen with combustible material at a temperature which causes a chemical combination. The continuous combustion of coal is possible only with a regular supply of air and an equally regular withdrawal of waste products. Work is required to provide this constant current or draft, either in the form of heat supplied directly by the fuel or indirectly by means of power obtained from the steam. Under either condition a considerable amount of heat is lost which, apparently, can never be saved by any inventions affecting the steam boiler. Usually both losses occur when blowers are used, as it is never possible to discharge the products of combustion at the temperature of the air. In the case of a boiler without a feed water heater, they can never be below the temperature of the steam. The table shows that 1 127 heat units are thus lost even with an economizer. Without it the quantity would have been above 2 000. Complete combustion is not possible without an excess of air, and thus a small gain brings with it a considerable loss, as the heated air is discharged at the same temperature as the products of combustion. With blowers this excess is likely to be greater than with a natural draft. The regular supply of air is an absolute essential of economy when the supply of coal is also constant. Air entering irregularly signifies loss of efficiency. It is in this respect that the various forms of mechanical stokers have the advantage of firing by

hand. The total heat lost up the chimney from a furnace would appear by the table to be about 2 100 heat units, or 18.4 per cent. Two methods have been worked out for recapturing some of this heat, and of these the feed water heater has played by far the more important part. It has taken on various forms, but the Green economizer is that which has seemed most effective. Any arrangement by which the feed pipes are placed in the path of the products of combustion will add to the economy of the boiler, although it may also add to the repair bill.

Attempts have been made to heat the air supplied to the furnace by means of the waste products, and the Howden system has proven successful in this respect. A fan is necessary for its operation, and work is thus expended by the blowing engine in the production of draft. One point worth attention in connection with all hot-air blasts is that the amount of oxygen in one cubic foot of air is inversely proportional to the absolute temperature. Consequently, at a high temperature a greater volume of air must be supplied to consume a given weight of coal; it therefore requires greater power to drive hot air in burning coal than cold air. There is much to be said on the subject of the location of a blower, whether it be in the fire room and used to force draft by pressure in the ash pan, or in the uptake, where it creates a vacuum to induce draft. In the latter case the temperature of the products of combustion must be kept comparatively low in order to prevent an injurious change of shape of the fan.

Intimately connected with the economical combustion of coal is the prevention of smoke, the latter being only so much unburnt carbon passing off into the air, to drop on everything in the neighborhood. All of our large cities have been troubled with the smoke nuisance, upon which many inventors have set their brains to work. One needs only to go through a city like Pittsburg to realize that there is room for improvement. In the main, it may be said that devices for smoke combustion lead to economy in the use of coal, but they often increase the total expenditure of money per year. The cost of coal is only part of the total expense, and repairs to smoke consumers and patent furnaces are often large. Unless a plant is of considerable size and is run continuously, they are of doubtful value. The various forms of mechanical stokers have the advantage over firing by hand both in economy and in smoke prevention. Yet much might be accomplished by better laws in regard to licensing

firemen. It has always seemed to me that a first-rate fireman with the ordinary grate is equal to any form of patent furnace, where there is a fluctuating demand for steam. There is a vastly greater difference between a good fireman and a bad fireman than there is between a mechanical stoker and a good fireman. A good school for teaching them would be more fundamental than mechanical devices of any kind. Yet it is only fair to add that the cheaper grades of coal can be burned on patent stokers where the feed is regular. This is a decided advantage, and furthermore the extensive use of soft coal must of necessity develop a good smoke consumer. Some are now fairly satisfactory. A few years ago I ran a series of tests with a patent furnace in order to compare its results with those obtained from an ordinary grate in a boiler alongside of it. The patent furnace was something like the Murphy automatic furnace, only it had a broader plate in the bottom. The coal was fed in on the sides, and a warm blast was thrown down over it from the sides throughout the length of the furnace. This blast was caused by an ordinary Sturtevant blower. I ran a dozen or more tests with the boiler, which was of the ordinary under-fired type, and found that on the whole it was not so economical in the production of steam as the ordinary grate. In the reduction of smoke it was very effective, by diluting the products of combustion with air to such an extent that the smoke seemed to be only a small percentage of the discharge from the chimney. The neighboring boiler with the plain grate discharged into the same chimney, and I watched it very carefully when run by a first-rate fireman. The amount of smoke was undoubtedly in excess of that discharged from the patent device, even when great care was exercised in the firing, but not to the extent usually seen in the ordinary factory chimney. The amount of steam produced per pound of coal was fully up to the very best practice. It has always seemed to me, therefore, that one of the essential features of economy should be the proper education of firemen and a more rigid requirement by the state inspector. As it is at present, almost any man who knows where water goes into a boiler and where it can be blown out sets out as a full-fledged fireman. He may be very unskillful in the handling of coal.

It seems strange that up to the present time no satisfactory method of keeping the heating surfaces of boilers clean has been devised. The loss of heat chargeable to this account is very great, and the loss of money is still greater. We find it necessary to provide heat-

ing surface equal to thirty-five or forty times the grate surface to attain any kind of efficiency, yet an effective method of cleaning the surfaces would permit us to reduce them very materially, and thus to lessen the amount of material put into a boiler of given horse power. The tubes of ordinary boilers are always more or less dirty, and the water side of the tubes is almost continuously coated with some non-conducting substance. I have seen a ship gain a knot's speed simply by blowing through the tubes with steam, and that without the expenditure of a pound more coal.

The small losses shown in the table from moisture, leaks through the brickwork, and unburnt coal, are sometimes serious, but they are simply matters of care. If a fireman is allowed to turn the sprinkler on coal he is likely to cost his employer dear in the course of a year. The same may be said of too frequent cleaning of fires. The leaks through the brickwork are greater than usually reckoned, and they are avoidable only by constantly plastering up the outside. It has seemed to me that a sensible gain in economy would result from plastering the outside of a brick setting so that every crack would appear at once upon its development. In the table the loss "not accounted for" requires some study, as it appears to be quite a large percentage. There is always this unaccountable deficiency, greater or less according to the care exercised in the test which has been made.

When we turn to the steam engine we find greater losses than in the boiler. The first and most serious loss is from initial condensation. Although the steam jacket has done much to mitigate this loss, it should still be used with judgment. For many years there was a controversy on the merits of the steam jacket, proceeding mainly from the fact that the different tests were made under different conditions, and not properly comparable. Some would pronounce the jacket as of no special advantage; others would find a gain of 25 or 30 per cent. There are engines in which this gain is possible, but only when the jacket is properly used. I have lately run a test showing that there is such a thing as over-jacketing an engine and losing heat by having too much jacket steam. The case is that of a triple-expansion engine, which developed about 533 horse power. The steam was supplied to the high-pressure cylinder at 184 pounds, and it passed successively through the high-pressure cylinder, the working side of the first reheater, the intermediate cylinder, the working side of the second reheater, and the low pressure cylinder,

into the condenser. Every cylinder and reheater was thoroughly jacketed with high-pressure steam from the boiler, and the exhaust from the low-pressure cylinder passed into the condenser, with steam superheated 100°. It strikes me that this was a waste of steam, although I have never seen a similar case in connection with the steam jacket. The record of economy was about as follows:—

Without any steam on the jackets or reheaters, the steam supplied to the engine was 12.19 pounds per indicated horse power.

With full pressure on all jackets, the steam used was 12.09 pounds per indicated horse power, showing no substantial gain.

With steam on only the high-pressure and intermediate jacket and on the first reheater, the amount of steam supplied to the engine was 11.47 per indicated horse power.

There were nineteen tests run in all in connection with this engine, and the results have not been completely tabulated for publication, but the point which I wish to bring out here is perfectly plain, and that is that a test with and without jackets, as at first conducted, would have shown no special advantage of the jacket; yet a further test, with a moderate amount of steam used in the jackets, especially in the early part of the passage of the steam through the cylinders, showed a gain of six per cent. It has always struck me that the difference between the tests of steam jackets is in the circulation, and that many of them fail from a poor circulation of the steam. The success of a jacket depends entirely upon discharging all condensed water, so that the latent heat stored in the steam may become useful.

One of the chief directions for Americans to work in the use of steam is in superheating. Much more has been done in this line in Germany than in our own country. With the improvement in oils, there is no reason why an engine should not be made to work successfully under a moderate degree of superheat. This reduces materially the necessity for jacketing, and effects a saving in first cost as well as an increase of efficiency.

When all is said about the loss of heat from an engine, I am persuaded that the loss from the leakage of steam by valves is much more serious than usually appears. Very few valves are tight, and a continuous leakage from the boilers past the valves or pistons to the air or the condenser is a great drain on the coal pile. One case which came directly under my observation was in the use of a piston valve for the low-pressure cylinder of a cruiser. We were making

about eight knots an hour on forty tons of coal a day. The replacement of the packing rings in the low-pressure piston valves reduced the leak of steam to such an extent that the ship was easily able to make nine knots an hour on about thirty-five tons of coal a day. The leakage was thus fully 60 per cent. of the steam used to produce the power, and this served only to heat up the sea water discharged through the outboard delivery.

Calculations on initial condensation seem to me, therefore, very inaccurate, excepting where a careful test has been made of the tightness of all valves. Gridiron valves seem, on the whole, most satisfactory. They are far preferable to piston valves, as their tendency is to become tighter with wear, while the tendency of piston valves is to become looser.

Not much remains to be done in ordinary water works towards gain in mechanical efficiency. As stated above, Mr. Leavitt's engine in Cambridge gave about 96 per cent. efficiency. Something remains, however, in reducing the losses of ordinary power stations. A question which every engineer has to face at some time in his life, and which every owner of a factory must face, is what are the necessary items of an economical power plant. It seems to me that they may be summed up about as follows: A well-designed and well-built battery of boilers, with natural draft, using either skilled firemen and a plain grate or the average fireman with some mechanical device for a regular feed into the furnace. Some form of feed water heater or economizer should invariably be used, and some type of superheater. This provides for the essentials of the fire room. So far as the engine is concerned, either a compound or a triple-expansion engine should be used, depending upon the special conditions. Using superheated steam, the steam jacket should be used sparingly. It might not be necessary at all on the high-pressure cylinder. Feed water heaters should also be placed in the line of the steam exhausting into the condenser. The mechanical efficiency is so much a matter of inspection during the manufacture, and the proper construction of the engine, that it ought to take care of itself.

DISCUSSION.

MR. H. F. GIBBS. Mr. President, I should like to ask Professor Hollis how many horse power can be obtained from one pound of coal containing 1300 British thermal units.

PROFESSOR HOLLIS. I should say eight and one half times as much as we get now. I have not figured it that way exactly. I know that from one pound of coal we realize 1 320 000 foot pounds. If that pound of coal was to be burned in an hour I should have to take a pencil and figure it out, but I think we should get a good deal more than we get now.

MR. GIBBS. In regard to jackets on jumping engines, I have one Blake pump, — no fly wheel, — which, if I shut off the jacket, will shorten the stroke as much as one and one-half inches, and nothing would bring it up but putting on the jacket again. I do not get as good a vacuum with the jacket shut off, and the question I should like to ask is, in the first place, if these jackets are too hot how would a reducing valve work on the jackets on the low-pressure cylinder? You know in the low-pressure jackets you get about the same temperature.

PROFESSOR HOLLIS. I think it ought to work all right, but I would not presume to tell you gentlemen anything on that subject; but on general principles I would put in a reducing valve rather than use a high-pressure steam valve.

PROF. LEONARD P. KINNICUTT.* I am afraid that I have very little that is of interest or new to say on this subject. I have listened to Professor Hollis's paper with great pleasure, for each year I am obliged to give twenty lectures to the mechanical engineers of the Worcester Polytechnic Institute, on fuels and the loss of heat that takes place in the production of steam.

The three chief causes of loss of calorific power when fuels are used under a boiler are — incomplete combustion, heating of the gases that pass up the chimney, from the temperature of the boiler room to the temperature at which the gases enter the chimney, and radiation.

As to incomplete combustion, the loss is due to part of the coal falling unburnt into the ash pit with the ashes; to part of the carbon of the coal passing unburnt up the chimney, and causing the smoke which has become so noticeable in the air of our cities during the past six months, and to part of the carbon uniting to only half the amount of oxygen which it is capable of uniting with, and consequently producing only about two thirds of the amount of heat that it would produce if it all united to the maximum amount of oxygen. The amount of loss that may be caused in these three ways by incomplete combustion often equals from 10 to 15 per cent. of the

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total calorific power of the coal. Yet this loss can, as Professor Hollis has said, be almost entirely prevented by good firing or stoking, and I also agree with him when he says that he prefers a living, thinking stoker, who understands his duties, to any mechanical device. The human stoker should, however, be trained for his work, and it is very poor economy to employ a man to fire our boilers who has no idea of the difference between poor and good stoking.

In Germany careful attention is given to the subject of firing, and, as you may know, in many of the cities of Germany there are schools for the training of stokers. These schools offer two weeks' instruction in stoking and the care of boilers. The fee is only about three dollars, and men who have been trained in this way are greatly in demand. Similar schools in this country would do much not only to increase the efficiency of a boiler plant, but would also have a decided effect on the purity of the air of our cities.

As to the heat lost by the heating of the gases that pass into the chimney, I have found that it is very often greatly in excess of that which should take place in good boiler practice. The loss is due not only to the difference in temperature of the air as it enters the grate and the temperature at which the gases pass into the chimney, but to the volume of air that is entering the grate and passing up the chimney and to the composition of this gaseous mixture. The amount of air that enters the grate can be easily controlled by a good stoker. Theoretically, eleven and one-half pounds of air are necessary for the perfect combustion of a pound of carbon, but in practice we find that we must use a little more than this, say from fourteen to sixteen pounds. Anything beyond this, however, is causing unnecessary loss of heat, and a little care in this direction may make a very decided difference in the coal bills. The composition of the gaseous mixture as it enters the chimney also makes a great difference in the heat required to raise a given volume of the gas through a given number of degrees. This loss is caused, as you all know, by the fact that it takes more heat to raise a given volume of nitrogen and oxygen through a given number of degrees than it does the same volume of carbon dioxide. A gaseous mixture of nitrogen, oxygen, and carbon dioxide containing only 7 per cent. of carbon dioxide will require 75 per cent. more heat to raise it a given number of degrees than the same volume of gaseous matter containing 14 per cent. of carbon dioxide will require. It may well be

asked, How can a stoker tell the composition of the gaseous mixture passing up the chimney, and govern his fire accordingly — he is not a chemist, and is not expected to know about gases or their analyses? This is all true, but there is a very simple device, described first, I think, by Professor Hempel, of Dresden, which can be attached to any boiler, by means of which, by merely noticing the height of a candle flame, burning in a tube containing an index card, and through which a very small portion of the gaseous mixture as it enters the chimney passes, the amount of carbon dioxide can be immediately read off. The larger the amount of carbon dioxide the gases contain, the longer will the candle flame be drawn out.

If there was only some way, as Professor Hollis has stated, of supplying pure oxygen cheaply to the fuel, instead of having to supply it in the form of air which contains only 21 per cent. of oxygen and 79 per cent. of nitrogen, a very great saving of heat would be possible. At the present time, however, there is no practical way of supplying oxygen except by using air. Some day it may be possible to do so, just as at the present time we are able to burn aluminum in oxygen not taken from the air but taken directly from a compound of magnesium and oxygen, known as magnesium oxide, and thus obtain very high temperatures. There are many compounds of oxygen and metals, like iron oxide; which occur abundantly in nature, and it is interesting, at least theoretically, to consider if some day it will not be possible to burn our fuels by means of metallic oxides, thus saving the large amount of heat that is now required to heat the 79 per cent. of nitrogen that is mixed with the oxygen in the air.

WASTE HEAT ENGINES.

BY PROF. EDWARD F. MILLER, MASSACHUSETTS INSTITUTE OF
TECHNOLOGY, BOSTON.

[Presented November 12, 1902.]

The best steam engines of to-day utilize in the form of work but from 20 to 25 per cent. of the heat supplied to the high-pressure cylinder. Even at these low figures the engines are giving about 80 per cent. of the efficiency of the theoretically perfect engine.

The theoretically perfect engine, or the Carnot engine, as it is called, has no losses from friction, radiation, or absorption of heat by the pistons and cylinder walls. Its efficiency is found to be independent of the working medium used, whether steam, air, carbonic-acid gas, sulphurous anhydride gas, or any other substance, but to depend simply on the range of temperature worked through and the absolute temperature of the supply.

This may be illustrated by an example : —

Let us take a steam engine using steam at 150.3 pounds gage or 165 pounds absolute pressure and exhausting at 26 inches vacuum or at 2 pounds absolute pressure, and find the efficiency of the perfect engine.

The temperature of the incoming steam is 365.9°F. , or $T = 826.6^{\circ}$ absolute; that of the exhaust is 126.3°F. , or $T = 587^{\circ}$ absolute. These values are found in steam tables.

$$\text{The efficiency} = \frac{T_{\text{supply}} - T_{\text{exhaust}}}{T_{\text{supply}}} = \frac{826.6 - 587}{826.6} = 29 \text{ per cent.}$$

The actual engine, on account of radiation, cylinder condensation, and other losses, realizes but 80 per cent. of this and has a thermal efficiency of 23 per cent. It is evident that to get an efficiency of 100 per cent., even for the perfect engine, all the heat supplied must

be transformed into work; that is, the engine must exhaust no heat. The equation for efficiency may be written, —

$$\frac{Q_{\text{supply}} - Q_{\text{exhaust}}}{Q_{\text{supply}}} = \frac{T_{\text{supply}} - T_{\text{exhaust}}}{T_{\text{supply}}}.$$

An engine which exhausts no heat would evidently have the value $T_{\text{exhaust}} = 0$, or the temperature of the lower limits of the cycle would be 460.7° below 0° F. This shows that it is impossible to attain a high efficiency because there must necessarily be a large amount of heat exhausted to the condenser. The efficiency may be increased by raising the value T_{supply} in the equation for efficiency or by making the value T_{exhaust} lower.

In Germany steam superheated 300° F. is in quite general use.

A calculation for the preceding case with the steam superheated 300° gives for the perfect engine, —

$$\text{Efficiency} = \frac{1\ 136.6 - 587}{1\ 126.6} = 48 \text{ per cent.}$$

or $48 \times .80 = 38$ per cent. for the actual engine.

To obtain this high degree of superheating, a special superheater with furnace is required, and the extra cost *in heat* of the superheated steam should be considered when a comparison is made with an engine using saturated steam.

It is only recently that attempts have been made to increase the efficiency of an engine by reducing the temperature of the exhaust heat. It is of this work that I wish to speak.

Prof. E. Josse, of the Königlische Technische Hochschule of Berlin, has, during the last two years, perfected an engine in which the heat of the exhaust of the low-pressure cylinder is absorbed by sulphurous anhydride (SO_2), which is used in the place of the cooling water in a surface condenser. The SO_2 is vaporized by the heat given up by the condensation of the exhaust, and its vapor is used in a separate cylinder just as steam would be used.

The SO_2 , after leaving its cylinder, is condensed under pressure in a water-cooled surface condenser. The liquid SO_2 is returned to

the vaporizer by a small pump, thus making the cycle complete. The sketch, Fig. 1, will serve to show the general arrangement of such a combined engine.

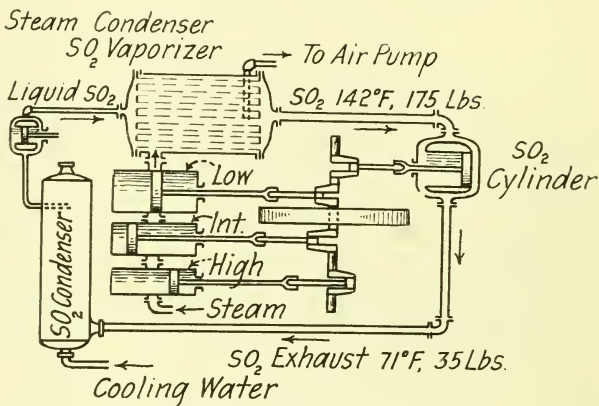


FIG. 1.

It may be interesting here to look at the pressure curves and total heat values of SO_2 and of steam, which are plotted on the same diagram, Fig. 2 (see opposite page). At 100°F . the pressure of SO_2 is 85 pounds absolute; at 160°F . the pressure of SO_2 is 220 pounds absolute, while that of steam is only 4.7 pounds absolute.

If in an ordinary surface condenser the temperature of the hot condensing water was 100°F . (a temperature commonly found) the substitution of SO_2 for the water would give a pressure of 85 pounds absolute. If the cooling water left is 160°F . it would not be possible to maintain a very great vacuum, but with SO_2 used in place of the water the pressure obtained would be 220 pounds absolute, an increase of 135 pounds for 60° increase in temperature.

If the cooling water leaving the SO_2 condenser is at 70°F ., then the SO_2 will be liquefied at 48 pounds absolute pressure. This temperature fixes the back pressure on the SO_2 cylinder.

Assuming that the SO_2 was condensed at 70°F ., what has been the gain? Take first the steam engine using saturated steam at 165

pounds absolute and with 26 inches vacuum, we found the perfect engine had 29 per cent. efficiency.

By the use of SO_2 the lower temperature of the cycle has been changed from 126.3° to 70° , a drop of 56° .

The efficiency figures $\frac{826.6 - 530.7}{826.6} = 36$ per cent. as against 29.

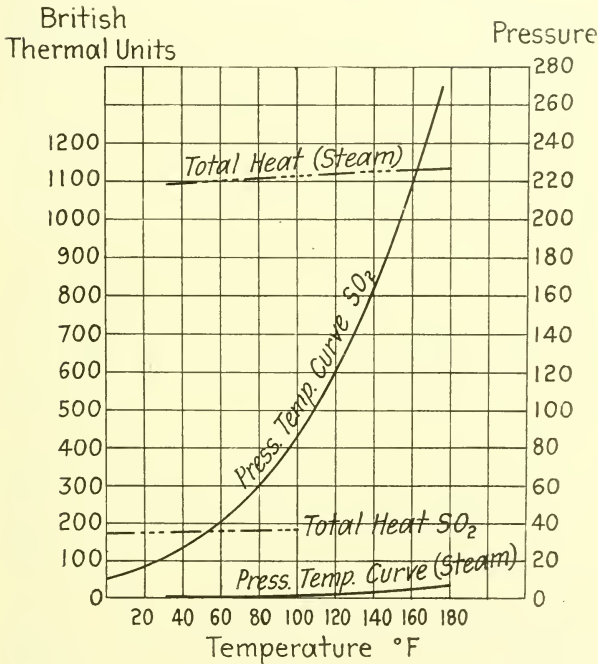


FIG. 2.

Applying the SO_2 cylinder to the same engine using steam of the same pressure but superheated 300°F , we have

$$\frac{1126.6 - 530.7}{1126.6} = 53 \text{ per cent.}$$

as against 48 per cent.

If the cooling water should leave the condenser at a temperature lower than 70° F. the back pressure on the SO₂ cylinder would be less, more work would be done in that cylinder, and the efficiency would be greater.

The results of a number of tests on this engine are given in the table on the opposite page. The indicator cards from the engine are reproduced on the diagram, Fig. 4, for test No. 8. It will be noticed that the vacuum on the low-pressure cylinder is not as great as commonly used on steam engines. In this case the vacuum used is about 20 inches, or a 68.5 per cent. vacuum, as it is called. It has been found by experiment that although the steam engine gives more power with a high vacuum, it is better to run with a less vacuum when combined with an SO₂ cylinder. The extra power obtained from the SO₂ cylinder more than offsets the loss due to the poorer vacuum. The precise amount of vacuum for an engine would have to be determined experimentally, but it is probable that it would be about 70 per cent.

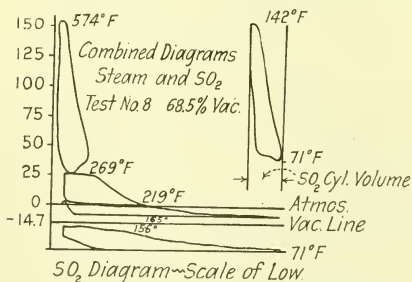


FIG. 3.

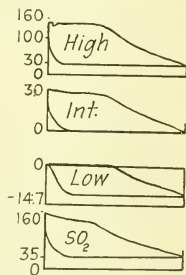


FIG. 4.

The combined diagrams, Fig. 3, show the range of temperature and of pressure worked through by each cylinder and the relative volumes of the cylinders.

The figure above and at the right in Fig. 3 is the SO₂ indicator card shown on Fig. 4, reduced to the same scale of volumes and scale of pressures. The figure at the bottom under the low-pressure diagram shows the same card with pressures reduced in the ratio of volume of the low-pressure cylinder to the volume of the SO₂ cylinder.

Tests on a "WASTE HEAT ENGINE." This engine consists of a triple expansion steam engine, condensing; having a sulphurous anhydride heat-saving cylinder attached. Tests by Prof. E. Joaze of Kgl. Technische Hochschule, Berlin, Germany

Arrangement of Apparatus during the Test		Steam engine working triple expansion										Steam engine working compound									
Speed — T. p. m. Units as Dynamometer As per test on Dynamo	Steam Engine	Water from the condensation traps led into the vaporizer										Water from the condensation traps led into the vaporizer									
		Superheated Steam										Superheated Steam									
		with high vacuum					dry saturated					dry saturated					at half condensing water				
		130.6	136.3	143.5	137.4	145	145	148	149	137	148	137	148	137	148	137	148	137	148	137	148
Temperatures °F.	Boiler steam — admission	210	189.5	210	191	209	212	211	230	230	230	208.5	235.8	210	230	208.5	235.8	210	230	208.5	235.8
Steam pressures	Boiler steam — admission	562	528	564	514.5	576	576	610	610	608.5	608.5	568.7	631	576	608.5	568.7	631	576	608.5	568.7	631
Per cent vacuum in condenser	Inlet pressure — High-pressure cyl. — per sq. in. above atmos.	175	219	221	214	210	210	221	224	227	227	175	219	221	214	210	221	224	227	227	227
Indicated output	Per cent vacuum in condenser	136.5	146.5	158	156.5	156.5	156.5	156.5	156.5	156.5	156.5	136.5	146.5	156.5	156.5	156.5	156.5	156.5	156.5	156.5	156.5
Horse power	High-pressure cylinder	89.2	95.5	106	85	79.5	89.5	88.5	88.5	88.5	88.5	89.2	95.5	106	85	79.5	89.5	88.5	88.5	88.5	88.5
	Intermediate cylinder	43.3	35.7	43.2	31.3	42.4	41.1	42.5	45.6	47.5	47.5	43.3	35.7	43.2	31.3	42.5	45.6	47.5	47.5	47.5	47.5
	Low-pressure cylinder	29.6	34.3	42.4	29.4	43.3	39.8	42.0	49.8	44.3	44.3	29.6	34.3	42.4	29.4	43.3	39.8	42.0	49.8	44.3	44.3
	Complete engine	162.1	181.2	231.2	153.2	180.3	183.5	183.2	211.8	180.5	180.5	162.1	181.2	231.2	153.2	180.3	183.5	183.2	211.8	180.5	180.5
	Condensation from the steam jackets and receiver	162.2	181.2	231.2	153.2	180.3	183.5	183.2	211.8	180.5	180.5	162.2	181.2	231.2	153.2	180.3	183.5	183.2	211.8	180.5	180.5
	Total Condensation	162.2	181.2	231.2	153.2	180.3	183.5	183.2	211.8	180.5	180.5	162.2	181.2	231.2	153.2	180.3	183.5	183.2	211.8	180.5	180.5
	per H. P. ind.	12.5	11.2	12.2	14.4	13.6	13.8	13.2	13.1	16.4	13.5	12.5	11.2	12.2	14.4	13.6	13.8	13.2	13.1	16.4	13.5
	SO ₂ vapour. Admission to cylinder	132.0	133.7	151.7	122.7	137.3	157.1	155.1	158.9	153.5	152.8	132.0	133.7	151.7	122.7	137.3	157.1	155.1	158.9	153.5	152.8
	SO ₂ liquid. Outlet to Condenser	66.2	65.8	67.6	64.4	68.5	67.6	68.0	67.6	70.0	64.6	66.9	75.2	65.1	66.2	65.8	67.6	67.6	68.0	67.6	70.0
	Circulating water — inlet	29.6	49.9	49.9	50.2	50.2	50.2	50.2	50.2	50.2	50.2	29.6	49.9	49.9	50.2	50.2	50.2	50.2	50.2	50.2	50.2
	SO ₂ pressures	132.9	129.2	172.4	119.9	142.2	187.7	186.3	192.1	180.6	177.7	132.9	129.2	172.4	119.9	142.2	187.7	186.3	192.1	180.6	177.7
	(above atmospheric in lbs. per sq. in.)	31.2	33.5	34.8	31.2	35.5	36.2	34.2	38	33.2	34.8	31.2	33.5	34.8	31.2	35.5	36.2	34.2	38	33.2	34.8
	Indicated	42.8	56.8	56.8	31.0	50.1	57.6	61.3	64.7	66.0	48.0	55.6	40.8	39.6	42.8	56.8	56.8	31.0	50.1	57.6	61.3
	Output — H. P.	34.4	34.2	37.0	30.5	34.5	40.0	37.9	33.3	42.1	39.4	39.5	34.6	37.2	34.4	34.2	37.0	30.5	34.5	40.0	37.9
	in per cent of steam-engine	36.5	32.8	33.2	47.3	39.5	34.6	34.8	—	38.9	34.4	33.9	39.5	39.1	36.5	32.8	33.2	47.3	39.5	34.6	34.8
	Consumption of waste steam per 1 H. P. per hour lbs.	177.4	168	211	137.2	195.4	192.1	223.9	217.9	222.3	169.8	196.1	129.4	113	177.4	168	211	137.2	195.4	192.1	223.9
	Indicated	151.8	143.8	177.2	114.2	174.3	176.2	202.9	201.9	201	159.8	180.2	141.9	80.7	151.8	143.8	177.2	114.2	174.3	176.2	202.9
	Effective	149.9	134	164.5	104.5	162.5	163.5	189.1	188.2	187.2	141.9	107.5	132	119.7	149.9	134	164.5	104.5	162.5	163.5	189.1
	Electrical	169.2	146.5	181	146.5	198.0	199.4	213.2	214.2	214.2	169.4	188.5	161.2	119.7	169.2	146.5	181	146.5	198.0	199.4	213.2
	Total steam consumption per hour — lbs.	9.7	8.36	8.6	11.05	10.12	9.86	9.55	9.85	11.5	9.7	9.6	10.22	10.6	9.7	8.36	8.6	11.05	10.12	9.86	9.55
	Steam consumption per 1 H. P. per hour — lbs.	—	11.69	13.06	—	12.486	11.330	12.468	12.584	13.316	12.144	12.066	12.526	13.40	—	11.69	13.06	—	12.486	11.330	12.468
	Total per hour — lbs. per hour for the comb. engine	79.5	99.1	76.8	89.4	82.8	87.5	84.2	84.2	84.2	79.5	79.5	84.2	84.2	79.5	99.1	76.8	89.4	82.8	87.5	84.2
	Electrical Output — 1 H. P.	85.5	86.2	83.8	87.5	89.1	87	90.8	92.5	90.5	89.8	92	89.8	92	85.5	86.2	83.8	87.5	89.1	87	90.8
	Mechanical Efficiency	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Quantity of circulating water in gallons	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Electrical Output — 1 H. P.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Mechanical Efficiency	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Number	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	5	6	7

* Dynamometer assumed, 95%

der. It shows the pressure needed in a cylinder of the same size as the low to do the same work as is done in the SO_2 cylinder.

Sulphurous anhydride does not attack iron or composition.

The SO_2 cylinder does not require cylinder oil, as the SO_2 vapor is of a greasy nature.

SO_2 when combined with water makes sulphurous acid; there is, however, no danger from any acid formed, for should the vaporizer or the condenser leak, the SO_2 being under the greater pressure would escape into water, which is constantly changing.

APPLICATIONS OF THE WASTE HEAT ENGINE.

Besides its use in connection with the steam engine, the SO_2 cylinder, vaporizer, and condenser may be used to recover some of the waste heat of the exhaust of gas engines, to recover some of the heat from the flue gases leaving a battery of boilers, etc.

The gas engine, as it is now used, has a higher thermal efficiency than the steam engine. The exhaust pipe of a gas engine is frequently of a dull cherry red color, showing that there is a large amount of heat lost. If now this heat is taken up by SO_2 and some power gotten from it, it would seem that the combination of gas engine and SO_2 waste-heat-saving engine would be far more economical than the Diesel motor on the steam engine using highly superheated steam with waste-heat cylinder attached.

From estimates as to the relative cost of a steam plant of 200 horse power, including boilers, tandem compound condensing engine, piping, etc., all complete ready to run, and of a gas-producer plant of 200 horse power with generator, gas engine, waste-heat engine outfit, including piping and SO_2 supply, it seems that the latter is cheaper by a few hundred dollars.

DISCUSSION.

PRESIDENT MERRILL. Professor Miller's very interesting paper is now open for discussion.

MR. FREEMAN C. COFFIN. I should like to ask if the only additional cost of running is the cost of running the pump to return the SO_2 to the vaporizer, aside from the additional first cost and a slight leakage of SO_2 .

PROFESSOR MILLER. Yes; there is one point more. By referring to the pressure temperature curve of SO_2 you will notice that after you get to about 109°F . the curve rises steeper than it does at the

first part. That means you can get greater pressure in your SO_2 cylinder if you carry less vacuum and consequently a higher temperature of the discharge from the low-pressure cylinder. It is a matter which has to be determined for each particular engine — what is the best vacuum for the output, but as far as these engines have been tested the best vacuum for economy is in the vicinity of 70 per cent.

MR. COFFIN. One more question. You speak of the efficiency of the gas engine as not varying much with the load; is that efficiency based on the indicated horse power or the actual?

PROFESSOR MILLER. On the indicated power; the engine friction, being practically constant for the various loads, becomes a smaller percentage with increased power.

MR. COFFIN. The effect is quite different for a light load, I suppose, between indicated and actual power.

MR. GEORGE F. CHACE. Do I understand that the sulphurous anhydride in any way comes in contact with the steam?

PROFESSOR MILLER. Surface condensers are used in each case, the SO_2 being on one side of the pipes and the steam on the other.

THE PRESIDENT. Have you anything to say on the subject, Professor Kinnicutt?

PROF. LEONARD P. KINNICUTT. I wish to ask a question. Has any substitution for SO_2 been tried?

PROFESSOR MILLER. I do not know that any substitution has been tried. There are other mixtures that might be tried, such as are used for refrigerating work.

PROFESSOR KINNICUTT. For what price can it be bought in this country?

PROFESSOR MILLER. I do not know what price it is sold for.

MR. R. S. WESTON. May I ask Professor Miller how much SO_2 it takes per horse power?

PROFESSOR MILLER. I do not know as I can give you the exact figures, but I do not think you would need much more than a thousand pounds (enough to charge the apparatus) for 100 horse power. There is always a reserve of liquid that does not vaporize, so you have quite a little spare liquid that can be called upon in case of a sudden leakage.

PRACTICAL AND THEORETICAL PRECISION IN EVERYDAY LIFE.

BY WILLIAM B. SHERMAN, PROVIDENCE, R. I.

[Presented December 10, 1902.]

So long a time has elapsed since I have had the pleasure of being present at one of these gatherings, and for this reason being a stranger to most of you, it was with a great deal of reluctance that I accepted the kind invitation of your Secretary to say a few words at one of the winter meetings. I shall not give you any finished paper on water; and, although this informal talk had to have a title, I crave your indulgence if I digress from the subject.

As the world goes, many of us are too precise and over-exact in our everyday calculation, and others there are who are not particular enough; I believe there is a middle line. We should use tact, common sense, and good judgment in applying the proper accuracy to the subject in question in order to attain in the simplest manner possible the desired result. Often we pay too much attention to the smallest and most trivial details, and in this way fail to grasp the large rounded-up whole which we wish to accomplish.

A noted poet in one of his stanzas said something like this: "For every one that dies another soul is born." Babbage, the well-known mathematician, with no poetry in his being, but keenly sensitive to precise, accurate data, wherever found, took the poet to task, correcting this general statement to read, "For every one that dies one and one third are born." Now we read poetry for the beauties of expression and thought which it contains, not for chronological data, knowing full well that the author claims free license to juggle with facts and figures in any way he sees fit that he may give rhythm to his metrical verse; and, on the other hand, we take up Babbage's logarithms not for poetry's sake, but to facilitate the solution of long, tedious calculations which we desire to have most accurate and precise.

In this case I think the correction was uncalled for. I believe there is a middle line.

Some ten or twelve years ago I was actively connected with a very interesting court case which from its peculiarity gained some notoriety at the time—The Lynn Gas & Electric Company against 23 Insurance Companies: the plaintiffs claimed that a fire caused short-circuiting, the breaking of pulleys, and the wrecking of the main engine, while the defendants, taking the opposite view, claimed that the engine raced and finally went to pieces, and the fire was the result. The late eminent engineer, Charles E. Emery, of New York, was retained by the defence as an expert witness. He made an elaborate and exhaustive calculation as to the exact time it would take for the engine to reach the limits of centrifugal force and go to pieces, massing into one unit all of the moving parts, including the jack shaft and its pulleys, and stated as a fact that the engine under its accelerating speed would be destroyed in a certain definite time. Mr. Moody, the present Secretary of our Navy, commenced his cross examination something like this: “Mr. Emery, I wish to be correct in my notes and desire that you assist me, — I am not quite sure whether you said the engine would go to pieces in 1 minute 47.2 seconds, or 1 minute 47.3 seconds.” This exact theoretical testimony was placed in so ludicrous a light before the jury by the cross examining attorney that its value was entirely lost. There is surely a middle line.

Regarding expert testimony, a well-known judge, at a recent dinner given in one of our leading New England cities, stated: “In many sections of the country, and in the minds of many people, there has arisen a most violent opposition to expert testimony and a complete loss of confidence in its value.”

I have in my collection a drawing made in an engineer's office which shows the layout of two batteries of boilers in brickwork, with the linear measurements carried out to four places of decimals, — to the ten-thousandth part of a foot. Now 1-10000 part of a foot is about 1-1000 of an inch, or to be more accurate and precise, 1-833 of an inch. In good practical everyday work we do not attempt to set bricks and rough boiler castings so precisely as that.

I have been greatly interested in the work of your committee appointed to prepare a standard set of specifications for cast-iron pipe, and in the discussion by the members. In other lines of mechanical work standards have been adopted and have been proven of great value to all parties in interest. Why not have a standard for pipe, which is one of your largest yearly expenditures? If all users of pipe

in this country would agree on a standard specification a great advance would be made — prices would be less and deliveries more prompt. The great obstruction to the carrying out of the plan will be that many engineers have pet ideas as to how pipe should be made, and will be very loath to give them up. The introduction of these special requirements adds greatly to the cost, for the foundryman must charge up his extra expense to somebody other than himself. This is a time of combination in many lines — assume for the moment that all of the water works in this country were brought under one management: the engineer of such an amalgamation would, it goes without saying, be selected from the foremost rank of the profession; he would have standard specifications for everything in the way of material required, including pipe, in which only his own whims would be introduced, it might be for long bells or short bells, $\frac{1}{4}$ -inch or $\frac{3}{8}$ -inch lead joint, and other specialties to his own taste, but they would be *standard* for the *whole country*; and I have not the slightest doubt that water would be distributed to all of the consumers in these United States as efficiently, and as economically, as now.

In passing I would say that some thirty years ago the city of Fall River started with four classes of weights of pipe, making the outside diameter constant for all of the same nominal diameter.

Meters are another and very necessary adjunct to make complete a system of public water supply, and should be more extensively used. Water is a merchantable article when distributed through pipes, delivered to the consumer in the same manner as illuminating gas, and should be paid for in the same way, that is, by measurement. Why they are not attached to every service pipe is obvious — the first cost, cost of maintenance and large outlay for frequent testing, make their general adoption expensive. With no meter we let the consumer draw as he likes; but when we install a meter we insist on having a mechanism that will test to within a small percentage both for full pipe and needle stream. I believe that in this matter of meters there is a middle line which we should strive to attain. The first cost could be reduced, and the durability of meters greatly increased, if we would be content with a registration say within 7 or 8 per cent., always in favor of the consumer. If we can reduce the cost of the meter system by being less exacting in our requirements, then apply the saving to the purchase and placing of additional meters, we will have made a radical move in the right direction.

With a reduction of say 25 per cent., one-third more meters could be added for the same money.

When the Brooklyn bridge was first opened to the public a tariff was made for foot travelers, but it was soon found that the expense of collecting the pennies exceeded the revenue, and the bridge was made free. This was purely a business proposition quickly met, and the meter question may be met as promptly in a similar way: bring down the cost by adopting a low-priced yet durable meter that will answer our purpose for the *majority* of consumers, instead of asking for a mechanical detective of watch-like accuracy and precision in its construction, whose use is to round up the few who allow small leaks to continue or the lesser few who may endeavor to procure water at no cost whatever.

In these remarks I do not wish to be understood as decrying theoretical formulæ or close calculations — they have their proper place; but I think most of you will agree with me that sound judgment based on practical experience takes the front rank and serves as a wholesome check to theory.

The late George H. Corliss, inventor of the Corliss engine, once told me of his early experience in determining the proper thickness of a steam cylinder. For information on the subject he turned to Tredgold, then the great authority. He went on smoothly for several pages, following the calculations and reasonings, and felt elated that the information was being so easily reached. On reading the closing paragraph, however, which stated that “in order to meet all uncertainties of the assumptions in the foregoing calculation, it will be well to double the result last obtained,” he said he closed the book and never referred to it again.

This Association has had an existence of some twenty years and now has a membership of 600, representing over 230 different water works throughout the country. During all this time between 200 and 250 papers on a multitude of subjects bearing more or less closely on the business in which you are engaged have been presented; and while many of them have given a detailed account of some one feature of a water-works system, only about 20 of them have been descriptive, as a whole, of the works which you represent.

Now, this is an age of specialists. There was a time when the successful civil engineer was supposed to be competent to lay out railroads, design bridges, water and gas works, sewerage systems, foundations, etc. All this is changed — to-day men devote their

entire time and energy to some particular branch of the profession, and you are specialists in your line; the majority of you being superintendents of water works engaged in the practical work of construction or maintenance, or engineers designing such works. I should like to see printed in our valuable JOURNAL a description of each water works represented in this Association.

Dr. Johnson said that knowledge is of two kinds: we know a subject ourselves or we know where we can find information about it.

I would suggest making the description in condensed form, avoiding details, simply naming the salient and peculiar features of the system.

Data such as this would place us in possession of information which could be followed up as each might desire; we should then know where to seek light and knowledge from our brothers' experience.

I suggest brevity in these descriptions, for, as you probably know from experience, a lengthy paper sometimes becomes tedious, especially if the reader is anxiously searching for some particular solacing morsel which he desires to absorb; and this puts me in mind of an anecdote of Lincoln, which many of you may be familiar with, but being pertinent, I will risk repeating it: when he was handed a voluminous report by a congressional committee on the examination of a new gun, the great man said: "When I send a man to examine a horse I expect him to give me his points; not how many hairs he has in his tail. I should want a new lease of life to read all this."

DISCUSSION.

MR. EDWARD ATKINSON. Mr. President, a gentleman once came to me to get some figures; after I had given them to him he said, "I suppose you know what a reputation you have?" I said I did n't, but should like to. "Well," he said, "there is a common saying that there are liars, damned liars, and statisticians." Said I, "My friend, figures never lie unless liars make the figures." That old saying has been lately changed, its present form is, "Liars, damned liars, and experts." [Laughter.]

The gentleman speaks of the meter system. I helped carry an ordinance through the town meeting in Brookline for a meter system for all private consumers; within two years after that I had evidence of the benefit of it to my cost and to the saving of the town. I paid my bills by my meter; one quarter the bill was 'way up, and the next three months it went higher yet. Then I dug up the pipe from

my house to my stable, and I found a leak which might never have been discovered except for the meter.

As to the standardizing of pipes, pipes are standardized in England at certain lengths, and when certain good friends of mine got a big contract for a great water service in Australia, the engineers in charge of putting it in took exception to the pipes because they were two feet longer than the English standard, and agreed to pay for the cost of cutting off the two feet rather than to disturb the standard.

There is one little incident which comes to my mind on the reference made by the speaker to Dr. Johnson. The last remark I ever heard about Dr. Johnson was this: "That the English language held a very unauthorized position until Dr. Johnson published his dictionary." [Laughter.]

THE RELATION OF WATER-WORKS ENGINEERS TO THE
FIRE SERVICE OF FACTORIES.BY EDWARD ATKINSON, PRESIDENT BOSTON MANUFACTURERS MUTUAL
FIRE INSURANCE CO., BOSTON, MASS.*[Presented December 10, 1902.]*

Gentlemen, — I am glad to meet you and to say a few words upon one of the most important problems of the day — the saving of the nation from the ruthless waste by fire, perhaps the greatest waste of a wasteful people. The mere ash heap, standing for absolute destruction, averages \$150,000,000 a year; the cost of distributing this loss through insurance companies comes to about \$80,000,000 more; the support of fire departments beyond any reasonable need, and the excess of water supply for the sole purpose of furnishing fire protection, carries the annual fire tax to about \$250,000,000. This sum is equal to at least 15 per cent. of the possible profit of the country in a prosperous year; often it amounts to a larger proportion.

The contracts of insurance against loss by fire amounted in 1901 to \$25,000,000,000, of which the Factory Mutual System carried only \$1,200,000,000.

In this latter system I have been interested, first, as an active director from 1863 to 1878, and since 1879 as the president of the largest company, now carrying risks for a fraction under \$160,000,000. In this I am but the administrator, but with the aid of such men as John R. Freeman, Joseph P. Gray, E. V. French, and others, representing every branch of engineering, we have developed an applied science in the prevention of loss.

You are used to figures and you know what they mean. When I tell you that the annual loss outside of our lines is sixty cents per hundred dollars of the insured value, and that the expense of conducting the insurance companies is thirty-three to forty-five cents, averaging forty; while in our system the average loss for seven years has been less than four cents, and the annual expenses, including our whole scientific department, less than six cents, making a total

of ten cents against one hundred, you can make some estimate of the many millions which may be saved by the Mutual System.

It is in this effort and in the work which we are now doing to extend our methods and to conduct what we sometimes call our "Missionary Department" that we ask your coöperation. There are few organized bodies of specially trained men who can do more than you can.

I shall not speak of the technicalities of your profession, — for that I am not competent, — but I will try to bring its importance before you by presenting the whole case from my own point of view. I hope I may succeed, but I realize, as probably few men can, how many aspects the same problem may have when regarded from different standpoints.

It is your duty to prevent a waste of water, in many cases filtered water, necessarily supplied at an increased cost. It is my function to assure the most abundant supply of water, and to provide for its lavish use when the emergency comes. You are obliged to consider the increased cost of pumping, and my function is to provide for a static pressure from the reservoirs under your charge that will draw most heavily upon them. Yet in recent years and in all our insured works we have done much to save water by the installation of the automatic sprinklers, through which the least volume of water does the most effective service. In that way, you will observe, we are coöperating with you, and we may ask you to join with us in making this means of preventing loss more certain and more efficient.

In dealing with this question of the fire service of factories I must first define the word "factories" as it will be used in these remarks. It means a textile factory, paper mill, machine shop, or other establishment such as is insured by the Factory Mutual Fire Insurance Companies of New England, whose risks are mainly in the New England and Middle States. What I shall say may be applied to other factories, but must be modified by the conditions of such other works.

My remarks must be directed mainly, if not wholly, to the representatives of public water works. Very few of our risks are supplied with water by private corporations. The difficulties which we have met in dealing with these private water companies have been among the influences that have convinced me that the supply of water to a town or city is one of the functions that the town or city corporation can perform more efficiently and at less cost than the work can ever be done for by a private corporation established for the purpose of

making a profit out of the supply of water. As I have said, we have been called upon to deal with very few private corporations, and when we have witnessed unreasonable demands made upon our members and have witnessed the lack of capacity and efficiency not uncommon in this class of water works, we have laid out, whenever possible, the substitute of private reservoirs and large tanks, in order to enable our members to ignore private water companies wherever their policy has, in our judgment, been bad. I call it bad policy when exorbitant charges and unreasonable so-called safeguards by meters and the like are imposed, as they have been in some instances upon the factories or works, on the success and progress of which the towns may mainly rely.

In dealing with the relations of the representatives of public water works with factories as defined, the first factor to be considered is the necessary coöperation between the water-works engineers and the underwriters. Their objects are the same; their methods may be the same; their relations with the agents and managers of the mills ought to be the same. Wherever there is any antagonism it is a fault either on the part of the underwriters, of the manager of the factory,—not often of the water-works engineers; but there is occasional friction and lack of agreement upon the common end. This friction corresponds to that which very often originates in the attitude of new members of the Factory Mutual System toward the underwriters. They bring into the Mutual System the very common attitude of the assured toward the stock underwriter, a very foolish, injurious, and bad attitude, yet almost universal; namely, to regard the underwriter and his policy of insurance as a necessary evil, for which the premium is to be squeezed down to the very lowest possible limit, whether it represents the cost of insurance with the necessary profit to the Stock Fire Insurance Company, or whether it represents a premium so low as to be less than cost and to lead to the bankruptcy of the insurance companies if persisted in.

The next aspect of the underwriter in the mind of the average of the assured outside the Factory Mutual System is to regard the inspector as a nuisance, as a man who may be kept out as long as possible from the premises, aided as little as possible in finding defects and dangers, and often one who may be imposed upon by hanging up cheap and nasty hose in order to make an appearance of being ready to cope with a fire.

I recall a rather amusing incident. Many years since a large agri-

cultural tool works came into the Mutual System, having not long before settled a loss with other companies. Shortly after a small fire occurred in one of their buildings with little or no injury to any stock. Our former vice-president, Mr. William B. Whiting, visited the works and looked over the premises, then turning to the agent said, "Put on your men; repair the building; send us a copy of the account from your books, and we will send you a check." "What did you say?" said the agent. Mr. Whiting repeated his words. "Is that all you have to say?" said the agent. "Yes," was the reply; "why not?" Rejoinder: "We did not expect such a mode of settlement. You do not appear to try to scale down our claim." "No," said Mr. Whiting; "why should I? You are honest, are you not? You will make a fair claim and our purpose is to pay you. That is why we exist: to pay an exact and just measure of indemnity for loss by fire."

What are the causes of friction and misapprehension which occasionally arise between the water engineers and the factory mill agents, leading to urgent demands for meters and other serious obstructions to the fire service, and leading to what may be unreasonable demands or charges for keeping the water ready to supply sprinklers and fire apparatus? One of them is said to be the taking of water from the fire service for other purposes, thus avoiding the just rates which are charged for the water supplied for other purposes than the extinction of fire. There is no doubt you could prove that water has sometimes been stolen from fire pipes. I can assure you that when water has been taken in this way by any factory belonging to the Factory Mutual System and insured by them, it is unknown to the treasurer or to the owner. I think their verdict would be that any man who would steal water from a water supply under such conditions would not be fit to be trusted with the management of the factory. If you could prove to the Factory Mutual underwriters that such frauds existed and were known to the principals, we should regard such members as under the suspicion of what is called the moral hazard, unfit to be associated for mutual insurance with their fellow members.

My reason for this confidence is, that what is commonly called the moral hazard, namely, the danger that property will be set on fire or permitted to burn in order to collect the money from the underwriters, is non-existent in the Factory Mutual System. The company of which I am president has existed for over fifty years. In

that fifty years there has been but one suspicion of a fire intentionally set in order to collect the insurance money, which led to that risk being dropped at once; and even that was an unjust suspicion, removed some time later by the confession of the incendiary.

Let us now take up this subject from the point of view of the owner of a factory insured in the Factory Mutual Companies, and of the underwriters. All these risks are thoroughly protected with pipes and hydrants, with reservoirs or tanks; with very rare exception they are supplied with water from two sources, one of which is usually the public water supply, the other private. In many towns and cities these works yield the principal support of the people of the town or city and of the shops and other small establishments which have gathered around them. By so much as these works have laid down pipes and placed hydrants, is not the town or village corporation saved from a heavy expense? Suppose these great works did not put down their own pipes and hydrants, would not the town, city, or village be under the same obligation to extend the public water works and the public fire apparatus for their protection as they are for the business blocks and lesser works which do not put in their own safeguards? Are not the citizens of the town saved a large share of the taxes which would otherwise be imposed upon them for the purpose of extending the public water and fire apparatus for the protection of these mills? It would seem to me that sensible officials of cities and selectmen of towns should supply all the water needed and all the necessary facilities for putting out a fire if by so doing they save themselves a very large sum which they would otherwise be called upon to spend for putting in the pipes and hydrants necessary to the protection of these great works.

And again, if a protected mill is a little way outside the jurisdiction of the town or water company, and yet gives employment to a great many of the citizens, they might be rightly subject to a small charge when they used the water, but the idea of putting on a charge against the hydrants and sprinklers because they may at some remote time draw water from them seems to me rather an unwise economy.

Again, as to meters. What is the need of a meter in a fire service? Are there not plenty of methods for approximately estimating the quantity of water discharged upon a fire without putting in a meter that may obstruct and disable the whole apparatus and cause the destruction of the mill?

I put these ideas before you for what they are worth. I cannot

deal with the science of hydraulic engineering. I have no knowledge of the physical sciences. My function is to find the men who do possess expert knowledge, and then, whenever I can, convert their technical papers over into the plain and simple English that the average mill agent will understand. If I can then make him think that he found it all out for himself I am sure of getting the pumps, pipes, hydrants, and sprinklers to the fullest extent that we desire. We have printed a great many documents with which you are doubtless familiar: Mr. Freeman's analysis of hose streams, specifications for fire pumps, and the like. It took me about two years to get the friction of water in iron pipes reduced to such terms that I thought the average mill agent would understand it. I then printed these tables, and from time to time I have computed the relative cost of iron pipes, horizontal and vertical; of hydrants at the ground level, on the roofs and at vantage points, as compared to the cost of ladders and hose pipes; also computed the relative service. Even at the present advance in price of iron pipe the balance is very largely in favor of iron pipe as against hose and ladders; volume of water from roof hydrants as against ineffectual streams from hose painfully and dangerously carried up upon the ladders.

We have also made the plan and laid out the mill yard of an ideal mill, perfect in all its appointments at our present standard. In the Department of Insurance Engineering, on which I have made a beginning, we are publishing reports, of which I have examples with me. The report on the mill and mill yard, on the relative cost of service of pipes as against hose, and other matters, will presently be printed in No. 5, now going through the press.

I should now like to hear from you, and in the debate which may follow perhaps each may strike some snags which may be removed so as to give the water from your works a free and ample flow through our pumps, pipes, and sprinklers.

DISCUSSION.

PRESIDENT MERRILL. Mr. Atkinson's very interesting paper is now before you, gentlemen, for your consideration.

MR. ATKINSON. I shall be disappointed if you don't find some fault with me.

THE PRESIDENT. Mr. Walker represents one of the largest mill cities of New England, and I am sure we should be glad to hear from him.

MR. CHARLES K. WALKER.* Mr. President, I feel as though I was n't capable of contending against such a celebrated insurance man as the one who has just been addressing us. His paper is very good, it sounds well; I have noticed that the insurance people usually have the best papers; they are the best talkers, and they get the best of the water-works men. [Laughter.]

MR. ATKINSON. They always try to.

MR. WALKER. Yes, sir; and so far as Manchester is concerned, they always do. Now, I find that the city does n't have much of a chance to get in on these private supplies that are of so much benefit to the underwriters, and are said to be of so much benefit to the city, but the mill people do have a chance to get in and tap those city supplies. Mr. Atkinson says they are not honest, they are not good, square men.

MR. ATKINSON. Certainly I say that those who do it are not honest.

MR. WALKER. Well, they do it just the same, and if you will go around to any mill in Manchester,—I don't want to say too much because if they hear of it they will perhaps kick me downstairs the next time they see me,—if you will go around to any mill in Manchester you will find that they do steal water from these celebrated mill supplies. What do we get out of it? We have to build the reservoirs and provide the water, and all the insurance people have to do, as I understand it, is to pipe the mill. We don't collect one single cent from them for keeping the water in those pipes, but it seems to me that the city ought to have a fair compensation for keeping those pipes full of water so that these insurance men can have the benefit of the water in putting out a fire. If we bring the water to the mill and have it ready for them, I can't argue it out in any other way than that we should have a fair compensation at least for looking after them to keep them from stealing it. [Laughter.] But I won't take up your time, gentlemen, and I don't propose to get into any argument with this gentleman, because I know he is too much for me. But I say what I think always, and I do think we ought to have some compensation for looking after these things, for I know that folks do steal water from fire supplies.

MR. GEORGE H. SNELL.† The insurance underwriters ought to meet the water engineers and water boards more than they do. I

*Superintendent of Water Works, Manchester, N. H.

†Superintendent of Water Works, Attleboro, Mass.

have been on the water board in Attleboro for four years, and never yet have met an insurance man, outside of our local agents, except Mr. Atkinson. We frequently have a telephone inquiry from the underwriters' office in Boston as to what size of pipe is laid on a certain street in front of certain buildings, but that is about as near as we ever get to them. They don't seem to know our system, or the capacity of our pumps, and each time they telephone they ask what the pressure is; it does n't seem as though they made a note of it, because they repeatedly ask the same questions.

Now, with regard to sprinkler service and private hydrants: A new factory has recently been built in Attleboro which is insured by some mutual company, I don't know which, and they have put in two private fire hydrants in their yard adjacent to the factory. Those hydrants are entirely different from ours, so that we could n't connect our hose to them. Our hydrants all open to the right with a five-sided nut, theirs open to the left with a square nut, and there could be no connection made between our department and their hydrants. No one asked us what to put in, what we used, or anything about it; we simply ran our pipe to their buildings for them at their expense and by their request, and they did the rest. When they got their work finished we asked them to file a plan of their system, which they are going to do, — later. The plan they have at the present time does not really coincide with the lay-out, they having made some slight changes. After they had got the system all in they asked the chief engineer of the fire department to come and inspect it, which I had done previous to that, and, as I say, he found that there was no chance for the fire or water department to use those hydrants in any way. They have no hose themselves, but still they claim that they have complied with what the insurance people asked them to do. My idea would be that the insurance underwriters, before they put in these sprinkler systems and private hydrants, should confer with the water engineer or the commissioners and find out what would be best both for the town and for the factory. I believe that is a matter which should be looked into more carefully, and I think that the insurance underwriters should know what each town has to protect the buildings with, and should have it down so that they can refer to it at any time and know what the facilities are for the protection of the buildings.

MR. WALTER H. RICHARDS.* I heartily endorse what the gentle-

*Engineer and Superintendent of Water Works, New London, Conn.

man has just said about conferring with the local water department. It often happens that the engineer or superintendent may know as much about the local arrangement of pipes as the insurance people do. I have noticed that although the plans of the insurance people are very nice and proper generally, yet they are always made with reference to protecting the particular property that is insured by them, without regard to the other properties that may not be thus insured. It very often happens that if a six-inch pipe, for instance, was broken it would take the pressure off the entire city, and in case of a fire somewhere else there would n't be any protection at all. When they ask us to put three or four six-inch pipes into a mill property, those pipes ought to be put where they would be beyond the possibility of an accident.

Mr. Atkinson remarked about there being two supplies, one from the water department and one a local supply. Well, it seems to me that where they are connected, as they usually are, by a check-valve, it is very possible that both supplies may come from the same source. That is my experience with check valves. I think there ought to be a consultation between the water department and the insurance people always before any plan is adopted, for the water department has interests outside of a particular mill and must protect them.

MR. THEODORE H. MCKENZIE.* One of the most important things that this Association can do is to appoint a committee for the purpose of determining a fair rate for the rental of water for fire protection by automatic sprinklers, standpipes, and hydrants, located on private manufacturing property.

There is no one thing that water companies have so much difficulty over as the collecting of a reasonable rental for such service. I believe the Manufacturers Mutual companies have a great deal to do with causing the difficulty.

I believe the insurance agents tell the manufacturers that they ought not to pay for fire protection, as they do not use much water, but the water companies are obliged to lay and maintain large pipes in the streets leading to the factories, and also to maintain a constant pressure in the pipes, and provide for the interest and depreciation on the large outlay. As the manufacturing business grows and the uses of water increase, the manufacturers put in private water supplies, usually pumping from a river or pond, and use the public water supply for fire protection only.

* Civil Engineer, Southington, Conn.

This Association should determine on and recommend a reasonable and proper rate for the use of water for fire protection, one rate for pumping works and another rate for gravity works, as the cost is much larger in the former case.

As to the honesty of water takers: As a rule, I believe nearly every one will take water and not pay for it if he can do so and not be discovered. A few years ago there was an instance of taking water in a surreptitious way from the system under my management at a large factory where there were hydrants, standpipes, and sprinklers; the use of water became so large that the factory people decided to pump their water from the river except for fire protection, and we were collecting a very small rental for water for fire protection. One day we were obliged to make repairs on the main pipes in the street near the factory, and soon after we began the factory operatives were standing around on the streets and informed me that the factory could not run, as they had no water to fill the boilers. I found that the engineer had been using water from the fire protection pipes for two years to run his boiler (150 H. P. or more). I have discovered other cases of the same kind where pipes for fire protection only have been tapped for use in factories.

The insurance people, especially the Manufacturers Mutuals, are making a great deal of money and paying large salaries, and the water companies are doing the insuring and getting nothing for it. The insurance companies ought to divide their profits with the water companies, or we should determine on a fair and reasonable rate for private fire protection and collect it.

THE PRESIDENT. I will say for the information of Mr. McKenzie that the whole subject of private fire supplies is now in the hands of a committee which has recently been appointed to consider it. I think the remarks of Mr. Snell are very pertinent, and that he has voiced the experience of a great many water-works superintendents. At the present time I myself am struggling with a similar proposition to the one which he mentioned. It came to me in the shape of a blue print from a factory which is just being established in our city. Inasmuch as it is pretty well known that water is not turned on in Somerville until the contemplated piping system is approved by the Water Department, we usually get information of it in that way. But the insurance people, I think, have never consulted us in the matter at all. I believe they prepared a plan and submitted it to the factory people without any consultation with the Water Department of the

city as to whether it would conflict with the distribution system or work any injury in any way.

I think Mr. Coggeshall, of New Bedford, can say something of interest on this subject.

MR. R. C. P. COGGESHALL.* I was hoping that you would leave me out, Mr. President, although I could tell quite a story if I should relate all my experience. There is no question that practically all of our corporations are open to this charge of dishonesty in connection with the use of water. There is, however, one point which has not been touched upon here, which seems to me of a good deal of importance. I think if any member of the Association would, in the case of an unmetered supply, tap in an inch pipe around the main gate into the factory yard, put a meter upon this connection, closing the main gate when the water is really not being used, he would be surprised to see the amount of water that is going through the pipe, that is, the amount which is going through in actual leaks. It amounts to considerable in the year, and that is one thing which has always appealed to me as a good argument why there should be some charge for fire protection service.

The factory people and the insurance people now submit plans to our office of all extensions, but it is only recently that that has been done. When a mill is piped for the first time, they have always done it, but the trouble has been that there have been extensions made from time to time. In a majority of cases that work is done by the city and so we know all about it, but sometimes it is done by outside contractors, and the work has been done before we knew anything about it, and we didn't have a chance to inspect it, and that has been something of which I have complained. I think there ought to be more consultation between the insurance people and the water department in that regard than there has been in the past.

It is surprising how easily a fire pipe will be tapped when a supply is wanted for some purpose or other. It is supposed that all the water actually used by a factory is to be metered, but it is n't always so. It was only this last week, when I happened to be going through the works of one of our old established corporations, that I found a connection from the feed pipe to the boiler running outside the meter. I traced it up and found it had been tapped into a fire pipe. The gate was not open. I called attention to it, and was told that that

*Superintendent New Bedford Water Works.

was only for an emergency, in case anything should happen to the other pipe.

The insurance people have always maintained that sprinkler pipes are in their best and most reliable condition when left filled with dead water. I think this true. But we continue to find these sprinkler pipes tapped for all sorts of supplies. In most cases this is done openly and as a matter of convenience, the sprinkler pipe being near at hand. In consequence there must be more or less circulation going on within sprinkler pipes. The insurance people know all about this, and I never hear of any protest. Here is a case where practice and theory fail to agree. If the insurance people would insist upon the honest preservation of the integrity of the sprinkler pipes from the controlling gate outside, onward, and see to it that such a standard was maintained, they would compel water for all other uses to be obtained from a secondary pipe. This would be a step in the right direction.

I think the insurance inspectors should go a good deal further than they do. Their interest in a way is perhaps identical with our own, and if there are any irregularities going on they are likely to discover it as quickly as we. I think they ought to notify us of every defect they find. But as matter of fact, when they find anything of the kind they keep very quiet about it.

There is another point I had in mind when I rose, and that is this : I know that Mr. Freeman has for a number of years been at work upon experiments in the use of proportional meters on all pipes, that is, a meter with a loaded check valve, by means of which an approximate indication of the amount of water which is passing through the pipe would be registered. It is certainly for the interest of the insurance people to have something of that sort, something which would not affect the value of the pipe so far as the fire pressure is concerned and yet which will at the same time act as a check upon the amount of water being used.

In relation to check valves, there was an interesting case in New Bedford, concerning which I have spoken several times before, but perhaps Mr. Atkinson has never heard of it. It was at the Acushnet Mills. They had a fire in the picker room. It was a hot evening in July, and of course all hands turned out and went down there. The fire pumps at the mill started, and in a very few minutes all the city steamers were thrown entirely out of commission, because the check valve had refused to close properly, and all the city mains in

the neighborhood were filled with salt water. All our check valves are now placed in boxes where they can be easily gotten at. They are examined by our department employees twice a year, and seen to be in proper condition, and the mill pays the expense of so doing. If the secondary supply had been fresh water in the above-cited case, we might not have noticed the failure of this check. You will readily understand that you would find it out pretty quick when salt water got into the city mains. The quality of a secondary fire supply I do not understand is ever considered. If of fresh water, is there not an opportunity, in case of failure on the part of check valves, that polluted water may enter the mains without the knowledge of the department officials, and may not this be the source of infection? For the benefit of those departments where these secondary fire supplies are of fresh water, I would add that our periodical examinations occasionally reveal a case where the check is not operating. I don't know that I have anything further to say at this time.

MR. WALKER. I should like to ask Mr. Coggeshall if he has had any experience in the shutting off of water. For instance, suppose there is a 4-inch pipe or a 6-inch pipe going into a building, so that they can get pressure, and you have a valve outside which serves to shut it off. But you find that the building is going, and you think it is about time to shut off the water; now how are you going to get to that gate? The building is going to fall, is likely to fall over on you, and there is that pipe running in there, wide open;—you can't get anybody to go and shut that gate, can you?

MR. COGGESHALL. In answer to that question I will say that my idea of a mill supply, and it is one we are now introducing in New Bedford, is that there should be simply one connection to the mill. That connection should be ample, but there should be only one. Then, upon the running main on each side of the mill supply you put a gate, in addition to the gate which controls the supply into the mill. In case the water is shut off outside for any purpose on either side of the mill, it isn't necessary to actually shut the mill supply off. The gate which controls the mill supply should always be located at a reasonable and safe distance from the mill so that it can always be got at in case of fire.

That very problem has come up this last week with the famous old Wamsutta Mill Corporation in New Bedford, which is the largest corporation we have there. They have some ten or eleven connections with the mains abreast of the building, in very much the condition

Mr. Walker suggests. Each one of those is like a service running out of the main. We propose to do away with all of those connections and enter the property from another street with one main of ample size, having the controlling gate where it can be always easily gotten at in case of fire, and run the pipe into the mill yard, and have all the connections with the sprinklers come out of the mill main pipe instead of out of the street main. The idea is that in case of a big fire there, as soon as the mill fire pumps get to working in good shape to hold the pressure, to shut the connection between the city and the mill, and let the mill take care of itself, leaving all the city hydrants for the city fire department. That is my idea of the way the thing ought to be handled, because it would be very disastrous to have a pipe of this size break where you could n't get at it.

MR. SNELL. There is one more thing which I did n't think to speak of while I was up before, with regard to charging for private fire protection and sprinkler service, in connection with this case I spoke of, where those hydrants were put in which would be of no use to the department. At the time the owner got ready to fill his tank, — he has a driven well and proposes to pump what water he uses, we simply furnishing him with drinking water and water for the sprinkler service, — after he got it set up, he telephoned to us and wanted to know if the town would n't fill it *gratis*. I told him certainly not; that he would have to take it through the 2-inch connection and pay for it. He said he was told by the insurance people that we would fill it without charge. So it seems that the insurance people try to make the manufacturers believe that we will give them a good deal more than they are really entitled to. In regard to stealing water, I believe that there are lots of people who will steal water who would not steal gold dollars to put in their own pockets. Some time ago, in a place where we relied on a meter, and where the party had been using about 4 000 feet a month, we found that the meter had been cut out. We asked him what he had done that for and he said they were testing a lot of water closets they had in the building, and they could n't afford to buy water for that. A good many people seem to want fire protection in the same way. But we made an estimate of the amount of water this party had used and made him a charge, and he settled the bill.

MR. COGGESHALL. There is one more point which I intended to touch upon, and that is the use for other than fire purposes of the hydrants in mill yards. That practice came to be so general in our

city that we were finally obliged to take vigorous measures to stop it. It got to a point where it was costing more money to keep the private hydrants, that were not supposed to be used, in proper order than it did all the public hydrants in the city of New Bedford. Those hydrants were used for about every conceivable purpose. I remember a conversation I had with one of our mill treasurers in New Bedford — and I will say that I have known him from boyhood up and he is just as honest a man as ever stood in shoes ; I know him well and I know he believes exactly what he says : He said to me, “ Bob, just as sure as you are alive there was never anything of that kind done in my yard. Why,” he said, “ I would n’t allow it.” The next morning after this conversation I happened to be passing by the mill, and there was an Irishman using water from the hydrant to lay the dust. I went up to the office and said to my friend, “ Come to the window a minute and look out there.” He did, and he wilted. [Laughter.]

Our practice now is to put seals on all the hydrants, and the result is that they are all in good order to-day, and it is very seldom that we find the seals broken. When a fire occurs we get a prompt report of same, and in case we find a hydrant seal broken, as a rule a good explanation is made regarding same. There have only been two or three cases in which we have felt called upon to apply the fine, and then it has been paid without a murmur. A rather amusing thing occurred a little time ago when a mill agent came to me and said : “ I want to borrow your seal press for a little while.” “ What for ? ” I asked. “ Why, we want to open a hydrant for a few minutes in order to wash the windows. I will seal the hydrant up again and will return the seal to you immediately.” [Laughter.]

MR. HENRY V. MACKSEY.* I was engineer of the fire service inspection in Boston for a short time, and my experience with the underwriters’ agents was, as a general thing, very satisfactory. It is strange, perhaps, but our greatest trouble was with the inspectors of the Factory Mutual Bureau. They seemed to come into town from all parts of the country. I was surprised at Mr. Atkinson’s statement that most of his work is in New England, for some of these inspectors were Indians. They had an idea that nobody should be considered except themselves. They paid no attention whatever to our rules, and when we complained at their office the excuse given was that the inspectors did not know our rules, in spite of the fact

* Deputy Superintendent, Street Department, Boston.

that the rules were printed and hung on the valves all over the buildings inspected. They would break the seals without notifying the Water Department, and advise the occupants of the premises that it was all right, as they were the underwriters' inspectors. Those inspectors made no improper use of water, and their inspection was a good thing, still they were a nuisance to us and they caused considerable trouble. We had no such trouble with the inspectors of the Boston Board of Underwriters: we could round them up after a while, repeating our complaints so often that their superiors would not allow them to forget the department regulations.

I have one place in mind in Brighton, where there are beautiful grounds and lawns and a half a dozen hydrants. Every time a Factory Mutual inspector descended on that place during the summer the grass grew greener; but the inspector has gone, he is not in town, we can't do anything except inspect the hydrants once more and re-seal them. One reason why the water department is entitled to recompense for fire service is that it has to keep up inspection and seal and re-seal valves and hydrants.

It is very true, as Mr. Atkinson says, that not one in a thousand water takers is dishonest. I suppose that not one in a thousand of the inhabitants of Boston is dishonest, and yet it costs the city considerable for a police force, and it cannot get along without it. If we could hire horses to haul our fire engines and only pay for them when they actually work, and the owners of the horses would keep them in good condition, all ready to hitch up when wanted, and would only charge for the time taken to haul the engines to and from fires, we could have a fire department at small expense. Unfortunately, we have to pay for horses the year round, to pay firemen the year round, whether working or not. As the main object of the sprinkler and other private fire protection systems is to protect the premises where they are installed, it seems to me that that property should pay a liberal part of the charge.

We found quite a number of cases where people took water from the fire service for other than fire purposes. We never said they stole it, although in many cases we could have proven that they did deliberately steal it. In some cases the owner was aware of the fact; in most cases I suppose he was not. But you can understand the position of the man who discovers such a case. He is usually a city employee in a very low grade, he does not amount to much politically nor officially, whereas a wealthy property owner may have con-

considerable influence, and if the inspector makes a straightforward, honest report, and calls things by their right names, and states that certain people were stealing water, he might have to worry for a month or two as to whether his salary would be increased or suddenly decreased. So we tried to stop the improper use of water, saying nothing about what had been done, merely getting things right and avoiding trouble. We were not always assisted as I think we should have been by the underwriters' inspectors. I should judge from Mr. Atkinson's statement that the Factory Mutual Company is not troubled very much that way. If we could turn off a water taker as easily as Mr. Atkinson can turn off a policy holder whom he thinks is not fair we would have no trouble ; but we must supply water to honest men *and others*. There are cases where I think the underwriters' inspectors might assist us. I know of one case in Boston where we had to argue with the owner for over a year to stop his engineer from using water improperly. In the meantime two sets of insurance inspectors had been over the building. They knew just as well as we knew that the water was being improperly used, but they never objected, although it was strictly contrary to their own rules that water should be taken from the system for anything but fire purposes. They could hardly fail to see it, because the main supply pipe for fire purposes was constantly dripping.

I read through the underwriters' rules very carefully when I went on this class of work and thought, if the underwriters will make people live up to them what a great help it will be. I called the underwriters' attention at one time to the fact that a party was filling his fire supply tank through a by-pass on a fire supply pipe. That was against the rules I was working under. I reported to my superior several times, but he was apparently unable to stop it. I went to the underwriters' office and asked if that wasn't against their rules. They said it certainly was, and they would be very much pleased if I would stop it. They did not stop it, although their rules distinctly stated that water must not pass through the fire pipes to the tank, but only from it.

The underwriters do not always help us as much as they should, and I think these private systems put the cities and towns to considerable expense, for which they should be reimbursed. In Boston the Water Department is supposed to live by its own revenue, and it has been able to do so until recently. Now it is not able to supply the general fire protection that is necessary, because of lack of means.

It is only fair that where it has to lay mains, inspect services, and inspect the buildings, some revenue should come to it to help bear the burden.

THE PRESIDENT. Mr. Chase, of Derry, N. H., has been laboring with this question for some months past, and we would be glad to hear from him.

MR. JOHN C. CHASE. I have listened with a great deal of pleasure to Mr. Atkinson's interesting paper, and would not be disposed to offer anything in the way of comment except for the fact that he seemed to think that he was going to run up against a regular Donnybrook Fair here, and that he would not feel satisfied or think he had got his money's worth if he did not go away with a broken head. [Laughter.] So it seems to be up to us to find all the fault with him that we can.

MR. ATKINSON. That is what I expected, and is just what I want.

MR. CHASE. I think it is pretty well known in this assemblage that I have been a non-believer in charging the individual consumer for water that is used for fire purposes, holding that so long as the water department undertakes to furnish a supply for fire protection it should make no difference to the consumer whether the water was taken from the public hydrants or used through a properly supervised private system. But that is neither here nor there. The only comment I have to make is this. I understood him to say that he thought the mantle of the water department should be extended over Factory Mutual clients whose establishments were outside the city limits. I know that charity should cover a great many things, but it strikes me that this is going a little bit too far. When a corporation, as is frequently the case, locates outside the city limits for the express purpose of evading the taxation, required in part for the maintenance of efficient water and fire departments, I think that it should be shown no favors whatever. This is all that I have to offer in the discussion.

MR. ATKINSON. I have made a few notes as we went along, gentlemen, and I should like to say a few words now in reply. First, our friend from Manchester says there is no question that every one of the corporations is guilty. Well, whom do I deal with in Manchester? For instance, I deal with the treasurer of the Amoskeag Company, and the other treasurers; I deal indirectly with the agents in charge of the mills. I am sure that not one of

those men would permit water to be taken surreptitiously. If they knew of such a case they would stop it instantly. I know them all. Now, I would like a case, a specific case, mentioned here. No names need be given, but let me have a single instance and you may be sure of a complete inquiry.

Again, it is said that actual leaks might well be paid for. That is a suitable matter for negotiation between the corporations and the water board. It is said that extensions should be submitted. They certainly should, that is surely a matter between the corporation and the water board. What have the underwriters to do with it? We may advise, but the corporation executes.

It is intimated that the underwriters should pay something. Who are the underwriters, speaking now only of the Mutual underwriters? We are only the agents of the members, in custody of their money. We have no money of our own; no capital. We receive the annual premiums, so called, from which we deduct the losses and expenses, and at the end of the year we return to the owners all there is left. The Mutual underwriters are not organized to make money; they are organized to save money. So much for that point.

A case is mentioned where a corporation tapped into a fire pipe for an emergency. Is there any objection to that, with honest men? Why might they not properly protect their fire apparatus and their engine and their works against an emergency? Isn't that an easy thing to be arranged with such men as those I have mentioned, and with men of the character and standing who are in charge of the mills in Manchester, New Bedford, and elsewhere?

The Mutual underwriters positively object to a tap being put upon a sprinkler service for any purpose whatever, because we do not want the water in the sprinkler service to move. We do not want the pipes flushed; we want the water to stay there as still as it can, even for twenty years. And why? Because when the water first goes in, what oxygen there is in the water causes corrosion up to a certain limit, and there it stops. If the water moves through the sprinkler pipes it will keep up slow corrosion, and by and by we will have our sprinkler heads filled up with oxide of iron so that they won't work. No intelligent mill man will permit a sprinkler pipe to be tapped for any purpose, except possibly for one-inch small hose. When any other tap is found our inspectors report to us, and it is cut off. Some of our inspectors may overlook it, but we

employ different inspectors with different kinds of spectacles. One man has an eye for one kind of hazard, and he sees that; the next man might overlook that fault, but he sees another. When our members object that our inspectors keep finding new faults, I reply, "What are they there for? If they didn't find fault, where would you be? That is what we employ them for. If any of them find any unreasonable fault, every report that we make to you has printed at the head of it 'If you think the suggestion unreasonable or injudicious, you will immediately refer it to the executive officers of the insurance company, and either you will be persuaded that the inspector is right, or we will instruct the inspector not to do so again.'"

The case of the Acushnet Mill is spoken of, where the check valve let in salt water. We have aided as far as possible the New Bedford commissioner to remedy that defect.

MR. COGGESHALL. That is true. I only brought that up as an instance of the unreliability of check valves.

MR. ATKINSON. He says that one connection at each mill is all there should be, but that should be ample. We shall be very glad to have that plan carried out in New Bedford and everywhere else. We desire to have the check valve removed from the point where in case of fire it would be difficult to handle it. That is for our interest as well as for yours, and our men are coöperating with you to that end.

Now, bear in mind, gentlemen, that we have had no big fire anywhere for seven years, so that a big draft of water for fire protection for the Factory Mutual risks is very infrequent; I hope it will continue so. But I know that at some time somewhere every forecast that the human mind can make will fail, and we will have another big loss. The last big loss that we had was in October, 1895, and that was in a most unexpected place and for a most unexpected cause.

Mr. Snell, of Attleboro, speaks about a man asking to have his tank filled free, and so on. If any insurance man told that man that his tank would be filled without charge, he had no authority to do so and he was a greenhorn. We never knew anything about it. If it had come to my knowledge that such instruction or information had been given, I should have told that inspector what to do. We have but one risk in Attleboro in the mutual companies, and that is this new risk in which the hydrants cannot be connected with

the city service. That brings up the very difficult question of the lack of uniformity in pitch of hydrant threads, etc. We do not in the mutual system depend very much upon the public fire department, especially in the towns of lesser importance. In the cities, such as Lowell, Lawrence, Saco, New Bedford, etc., there is usually a good understanding between every mill agent and the chief of the fire department, that the fire department may be summoned and will come; and while the chief engineer has, of course, the legal right to take the entire charge of putting out the fire, yet, as a rule, he leaves the mill fire department to do the work as far as possible, and not till an emergency arises is the public fire department called in. Our hydrants may occasionally vary from those of the city department, but we depend really more upon the private service than we do upon the public fire department; it is sometimes a necessity that there shall be a variation.

It is said that we should send the plans of our hydrant service to the water-works departments. Well, that is an excellent practice which has been established by us in respect to all the mills that we insure, but we do not execute the plans that we lay out. If extensions are not submitted, all that the engineer in charge of the water works will have to do will be to send to us, and we will see that it is done. We intend to coöperate perfectly.

"The insurance men ought to pay," says our friend from Manchester. I have said why we cannot pay, and that is because we have no money to pay with. We are only the custodians of the owners' money for each year. It is for them to negotiate what payments if any are due.

I wish that we could get around that difference in the pitch of threads and in couplings. We have in the larger cities to a very great extent, but in the smaller towns, and especially in those where we have but a single risk that matter does not always come to our notice. Whether those hydrants in Attleboro might well have been made uniform with those of the public department or not is an open question; probably it did not occur to the man who laid out the work before we took the risk. However, as I say, we have but one risk in Attleboro.

There is not a single mutual risk in New London; therefore the criticism of the gentleman from New London does not apply to the Factory Mutuals, to which I limit this discussion.

In reference to what Mr. McKenzie, of Southington, Conn., says, I will remark that I think we have no risk there. I may say that the

mutuals are divided into what are called the senior companies, which are the most conservative companies, in which are insured about eight or nine hundred millions, and the junior companies, which are extending their service over a wider area, taking in some mills of a different class. I do not recall the name of Southington on any of the senior route books, therefore I think Mr. McKenzie's criticisms must apply to the inspectors of other companies and not to ours.*

Mr. Macksey, of Boston, makes certain charges against the Factory Mutuals. My company has but four risks in Boston. We did have five, but there was a little friction between myself and the owners on some point in the protection, and I dropped the risk. We have but four in the whole city of Boston, and there are only two others in the junior mutuals. There are no Indian inspectors in their service. Reference was made to a certain risk in Brighton. I can identify that risk, and I know that no factory mutual company has any policy upon it. Hence, Mr. Macksey's criticism of factory mutual inspectors must be a product of his imagination, especially the Indian. Mr. Macksey made an excellent remark to the effect that there may be one dishonest man in a hundred who will steal water where there is one dishonest man in a thousand who will steal goods, and that we keep the police to take care of the rogues. The executive officers of the senior mutual companies do not insure rogues, and would quickly cancel policies if on proper information and proof they learned that a rogue had deceived them. It is the same with the bankruptcy laws. It is not worth 25 cents on \$100 to guarantee the prompt payment of every obligation entered into to-day, which aggregate the amount of \$130 000 000 of trade in the United States. More than 99 $\frac{3}{4}$ per cent. of those obligations entered into to-day in goods alone are paid in order that we may have our breakfast, dinner, and supper on our tables. Less than a quarter of one per cent. of merchants, manufactures, and traders fail; the bankruptcy laws exist to care for that small proportion. I am inclined to think that debts would be as promptly collected as they now are even if there were no bankruptcy laws in existence anywhere. Character stands for more than capital, and if you are not able to collect your debts at law, you perhaps would look out a little more sharply as to whom you trusted. It is not because most men are honest in the moral sense. Policy and honesty are synonymous terms. Unless his obligations are met, a man must go out of business.

*On correcting I find no mutual risk there.

The suggestion is made that the mutual risks should extend their benefits to other property. Well, they do spend the money for their own protection, but they do at the same time save other property to an immense amount. The recent conflagration in Paterson, N. J., came down under a gale of wind through the city upon a group of silk mills, a part of which were mutual risks fitted up under our instructions to defend themselves. There were six powerful steam pumps which could be put in operation, two of which were held in reserve. Lines of hose were run out to meet the fire in every direction, and so exact was their work that on the plan which we have prepared you can see the line where our risks and our apparatus stopped that conflagration, which, had it gone through the silk mill district, would have caused a loss of \$10 000 000 more, and would have ruined the city of Paterson in its silk industry. For seven hours these pumps were in operation without a break, and the strong underwriter hose prescribed by us did not burst in a single section. That is only one of many instances in which the apparatus in our factories has stopped fires which were beyond the control of the departments of the towns or cities.

Before the great Thanksgiving fire took place in Boston, although we had no interest in the property, I had tried to stop the construction of the building on Kingston Street in which it started, by representing to the mayor its danger; I had written him a seven-page letter stating what would happen if a fire started in that building: how it would cross the street; how the iron roof on the building opposite would come crashing down; how it would block the street and impede the firemen; probably killing some one, as it did; then how the fire would go on extending. Seven years later, when the fire occurred and the things actually happened that I said would happen, the fire marshal sent down to me and wanted to see a copy of that letter. I gave him one, and by changing the tense he made that letter the description of what had happened. For trying to do that service I was threatened by the architect with a lawsuit for \$20 000 damages for having injured his reputation. I invited him to sue and be, etc., but he never sued me. [Laughter.]

"The gentleman from Taunton says that the underwriters ought to know the pressure, etc., but that they are frequently sending to him to find out what the pressure is. I venture to say that you cannot go down to my office and look at a plan or record of a single mill where you will not find that we have the pressure, sizes of pipe, etc.,

all on record. I don't believe you can find one; so you don't very often have that question asked by us, unless we think there has been some change in the pressure. I believe I have had occasion to write to Taunton, because they depend upon the Holly system; is n't that so?

MR. CHACE. Yes, sir.

MR. ATKINSON. Well, we never had entire confidence in the Holly system, we therefore watch it. Then Mr. Chase, of Derry, N. H., speaks in regard to mills that are built outside the lines. We have n't any risk in Derry, but there are mills built outside the lines in some places for the purposes which Mr. Chase speaks of. There are other mills built outside the lines without the slightest regard to the rate of taxation, but for convenience of access and for other purposes.

Now, gentlemen, I think I have shown you how the mutual underwriters try to coöperate, and how, if any one of you wants and will give the opportunity for further coöperation, you can get it. And this leads me to the last point I will make. I advise you on some occasion to ask Mr. Osborne Howes, the head of the Boston Underwriters' Union, to come here and try to bring about coöperation with the other companies. The Underwriters' Union have adopted here in Boston an excellent system of inspections. One of our best inspectors entered their service years ago. They are doing everything they can do. They have rendered Boston the safest large city in the country. There is less conflagration hazard here now than there ever was before. I am sure they will do their utmost to coöperate with you.

I make no denial that there are certain, reasonable charges that might be made. There are other charges which we consider extremely unreasonable and injudicious, and which will imperil the protection of our risks; and those we take exception to. The class of men, some of whom I have designated in Manchester and that might be named in New Bedford, are to be trusted. Is there any head of a corporation in either city who would take water surreptitiously?

MR. COGGESHALL. No, sir; that is not the point I made. It is the other fellows who do it.

MR. ATKINSON. Then why don't you go right to headquarters?

MR. COGGESHALL. We do.

MR. ATKINSON. Then you stop it, don't you?

MR. COGGESHALL. Not always.

MR. ATKINSON. I have been a mill man and have run mills for many years before I became an underwriter. If I had in my employ a man whom I knew would steal water from the city fire service I should say, "That man will steal my property, and he quits my employment next week."

MR. CHACE. I want to say one word in explanation. We in Taunton have the utmost respect for the speaker and for his company, but I want to say with regard to the Holly system that for twenty-seven years we have practically not had a fire get away from the place where it started.

MR. ATKINSON. I know that.

MR. CHACE. And I may also say that I remember a fire occurring there not so very long ago, where the boiler room got so hot that the engineer and fireman could not get into it, and we put the fire out. In that case their fire pump was of no use at all.

MR. ATKINSON. That is so, and we now require all boiler rooms to be sprinklered. It has been one of the hardest jobs we ever had to do to induce the owners to do that. We do not now take a risk unless the sprinklers are complete.

MR. F. H. CRANDALL (by letter). This matter was under consideration at the recent annual convention of the Central States Water Works Association, held at Indianapolis. The subject was clearly and forcibly introduced by Mr. C. E. Inman, of the Warren Water, Electric Light and Power Company, of Warren, Ohio.

Attention was called to the possible impairment of the service by the wasting of water from such connections, both through sprinkler heads in time of fire and through leaks habitually and constantly permitted.

During the discussion a case was mentioned where one third the saving in insurance was charged for protection; one where eight dollars per quarter for each ten thousand square feet of floor space was charged, and they were considering the advisability of using meters.

Fifteen cents per annum per sprinkler head was suggested as a very reasonable rate, and metering received favorable mention.

Mr. Inman says, "Both the insurance companies and the plants using such services wish to get them for nothing, though it saves both thousands of dollars per annum. Neither likes a meter. They not only want the service free, but they want a free hand in the introduction of the system."

“This must be universally adjusted sooner or later, as their demands are unreasonable. They should pay what the service is worth. We have water-works conventions every year. It would seem that such questions as this would be settled on some uniform basis by the managers of water works, but it is passed by and the insurance companies get the service free in many cases, because the cities give it to them at the expense of the taxpayer, and if you and I do not do likewise, the trick is to make us trouble if possible, so as to get an important service for nothing, on which the insurance companies draw rich premiums and the owner of the local plant has his insurance cut to about one-third after the service is established. And both think the parties furnishing this service should receive nothing, as the plant is of local interest, and must be nursed with the bottle.

“Water companies who sell water for domestic use, being bound by their franchise, cannot afford to run chances of being defrauded without compensation, and it is my object in bringing this paper to your attention that a more uniform rate may be brought about by this Association. I know of no better place to start a reform in this matter than right here.”

At the close of an interesting discussion, during which numerous experiences of illegitimate use, unreasonably large services, and various methods of assessments were recounted, a resolution was unanimously passed expressing the sentiment of the convention in favor of an equitable charge for the protection afforded by private fire services.

STANDARD SPECIFICATIONS FOR CAST-IRON PIPE
AND SPECIAL CASTINGS.

[*Note by the Editor.*]

Since the publication of the last issue of the JOURNAL, the tables of special castings to accompany the Standard Specifications have been completed, and the specifications with the tables have been issued in pamphlet form. Copies of this pamphlet have been sent to all members of the Association; also to the superintendents or engineers of the large water works throughout the country not represented in the Association, and to all the pipe founders, with the following letter:—

715 TREMONT TEMPLE, BOSTON, MASS.,
FEBRUARY 16, 1903.

Dear Sir,—For the purpose of securing more uniformity in the forms and dimensions as well as methods of manufacture of cast-iron water pipes and special castings, after careful consideration of the subject by a committee consisting of Freeman C. Coffin, Dexter Brackett, and F. F. Forbes, and after conferring with a number of manufacturers of cast-iron pipe in the United States, the New England Water Works Association has adopted a standard form of specifications and standard patterns for pipes and special castings.

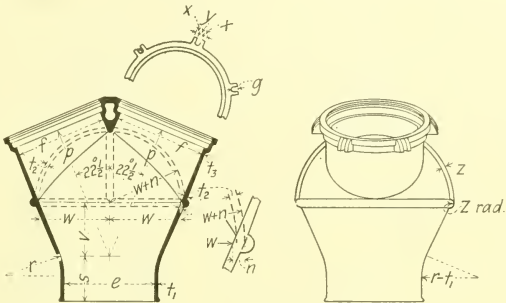
A copy of these specifications is sent you herewith, with the request that, so far as possible, you will make use of the same in ordering pipes for work under your charge.

The members of the Association and others desiring additional copies of the specifications may obtain them of the Secretary at ten cents each.

CHARLES K. WALKER, *President*.
WILLARD KENT, *Secretary*.

The tables of special castings which were lacking at the time of the publication of the December, 1902, issue of the JOURNAL are printed in the following pages, in order that the record may be complete.

Y Branches



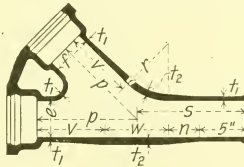
Type 1 12" to 48"

$g = 2.50"$ for 12" to 24" bells. $g = 3.00"$ for 30" to 48" bells.

$x = 1.25"$ " " " " " $x = 1.50"$ " " " " "

$y = 1.62"$ " " " " " $y = 2.00"$ " " " " "

$z = 1.00"$ for 12" to 14" bells, $1.25"$ for 16" to 30" bells, $1.50"$ for 36" to 48" bells.



Type 2 4" to 16"

Dimensions in Inches

Nom diam											Type	Class	Weight
e	f	s	p	v	w	n	r	t ₁	t ₂	t ₃			
4	4	11.5	10.5	7.18	6.64	3.18	6	.48	.60		2	K	105
6	6	13.0	13.0	9.27	7.46	4.27	"	.54	.65		"	I	175
8	8	14.0	16.0	11.85	8.30	4.85	"	.63	.75		"	I	280
10	10	15.5	18.5	13.94	9.12	5.94	"	.70	.85		"	H	415
12	12	"	21.5	16.54	9.92	5.54	"	.77	.95		"	"	610
"	"	16.0	"	8.00	9.79	1.19	30	"	1.10	.77	1	"	715
14	14	"	24.0	18.62	10.76	5.62	6	.83	1.00		2	"	785
"	"	"	"	9.00	11.30	1.29	30	"	1.19	.83	1	"	915
16	16	17.5	27.5	21.70	11.60	6.70	6	.90	1.10		2	"	1110
"	"	17.0	"	10.50	13.00	1.41	30	"	1.30	.90	1	"	1290

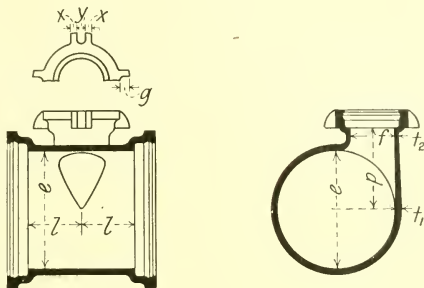
Y Branches

Table No. 8
(concluded)

Dimensions in Inches											Class	Weight
Nom diam		s	p	v	w	n	r	t ₁	t ₂	t ₃		
e	f											
18	18	18	30	12	14.7	1.17	30	.75	1.08	.75	D	1350
"	"	"	"	"	"	1.36	"	.86	1.26	.86	F	1490
20	20	"	34	13.5	16.4	1.25	"	.79	1.15	.79	D	1730
"	"	"	"	"	"	1.46	"	.92	1.35	.92	F	1940
24	18	9	30	12	14.7	1.17	"	.88	1.08	.75	D	1330
"	"	"	"	"	"	1.36	"	1.03	1.26	.86	F	1490
"	20	12	34	13.5	16.4	1.25	"	.88	1.15	.79	D	1690
"	"	"	"	"	"	1.46	"	1.03	1.35	.92	F	1900
"	24	18	38	15.25	19.3	1.35	"	.88	1.25	.88	D	2270
"	"	"	"	"	"	1.62	"	1.03	1.50	1.03	F	2600
30	"	12	"	"	"	1.35	"	.81	1.25	.88	B	2130
"	"	"	"	"	"	1.35	"	1.01	1.25	.88	D	2250
"	"	"	"	"	"	1.62	"	1.20	1.50	1.03	F	2580
"	30	18	48	18	23.7	1.25	"	.81	1.15	.81	B	3130
"	"	"	"	"	"	1.57	"	1.01	1.45	1.01	D	3790
"	"	"	"	"	"	1.89	"	1.20	1.75	1.20	F	4420
36	"	10	"	"	"	1.25	"	.90	1.15	.81	B	3000
"	"	"	"	"	"	1.57	"	1.13	1.45	1.01	D	3640
"	"	"	"	"	"	1.89	"	1.37	1.75	1.20	F	4260
"	36	18	54	21	28.2	1.41	24	.90	1.30	.90	B	4480
"	"	"	"	"	"	1.79	"	1.13	1.65	1.13	D	5500
"	"	"	"	"	"	2.16	"	1.37	2.00	1.37	F	6400
42	30	6	48	18	23.7	1.25	30	1.00	1.15	.81	B	3020
"	"	"	"	"	"	1.57	"	1.27	1.45	1.01	D	3620
"	"	"	"	"	"	1.89	"	1.53	1.75	1.20	F	4230
"	36	10	54	21	28.2	1.41	24	1.00	1.30	.90	B	4320
"	"	"	"	"	"	1.79	"	1.27	1.65	1.13	D	5250
"	"	"	"	"	"	2.16	"	1.53	2.00	1.37	F	6140
"	42	18	60	25	33.1	1.62	"	1.00	1.50	1.00	B	6280
"	"	"	"	"	"	1.95	"	1.27	1.80	1.27	D	7520
"	"	"	"	"	"	2.44	"	1.53	2.25	1.53	F	8950
48	36	2	54	21	28.2	1.41	"	1.10	1.30	.90	B	4090
"	"	"	"	"	"	1.79	"	1.40	1.65	1.13	D	4950
"	"	"	"	"	"	2.16	"	1.70	2.00	1.37	F	5790
"	42	10	60	25	33.1	1.62	"	1.10	1.50	1.00	B	6060
"	"	"	"	"	"	1.95	"	1.40	1.80	1.27	D	7230
"	"	"	"	"	"	2.44	"	1.70	2.25	1.53	F	8600
"	48	18	68.5	28	37.6	1.79	"	1.10	1.65	1.10	B	8570
"	"	"	"	"	"	2.22	"	1.40	2.05	1.40	D	10400
"	"	"	"	"	"	2.76	"	1.70	2.55	1.70	F	12450

Table No. 9

Blow-off Branches



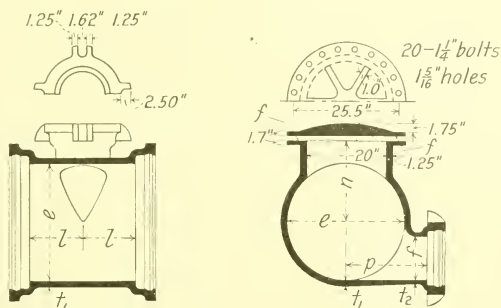
Dimensions in Inches									Weight	
Nom. diam.		l	p	t_1	t_2	x	y	g		Class
e	f									
8	4	12	7	.63	.48				I	230
10	"	"	8	.70	"				H	295
"	6	"	"	"	.54				"	305
12	4	"	10	.77	.48				"	375
"	6	"	"	"	.54				"	385
14	4	"	11	.83	.48				"	455
"	6	"	"	"	.54				"	470
16	4	"	12	.90	.48				"	580
"	6	"	"	"	.54				"	590
18	4	"	13	.75	.48				D	600
"	"	"	"	.86	"				F	650
"	6	"	"	.75	.54				D	610
"	"	"	"	.86	"				F	655
20	4	"	14	.79	.48				D	695
"	"	"	"	.92	"				F	755
"	6	"	"	.79	.54				D	700
"	"	"	"	.92	"				F	765
24	"	"	16	.88	"				D	915
"	"	"	"	1.03	"				F	1000
"	8	"	"	.88	.63				D	925
"	"	"	"	1.03	"				F	1010
30	"	13	20	.81	"				B	1190
"	"	"	"	1.01	"				D	1330
"	"	"	"	1.20	"				F	1470

Table No.9
(concluded)

Blow-off Branches

Dimensions in Inches									Weight	
Nom diam.		l	p	t ₁	t ₂	x	y	g		Class
e	f									
30	12	13	20	.81	.77	1.25	1.62	2.50	B	1260
"	"	"	"	1.01	"	"	"	"	D	1390
"	"	"	"	1.20	"	"	"	"	F	1530
36	8	"	23	.90	.63				B	1550
"	"	"	"	1.13	"				D	1750
"	"	"	"	1.37	"				F	1950
"	12	"	"	.90	.77	"	"	"	B	1610
"	"	"	"	1.13	"	"	"	"	D	1810
"	"	"	"	1.37	"	"	"	"	F	2010
42	"	15	26	1.00	"	"	"	"	B	2220
"	"	"	"	1.27	"	"	"	"	D	2510
"	"	"	"	1.53	"	"	"	"	F	2810
"	16	"	"	1.00	.90	"	"	"	B	2290
"	"	"	"	1.27	"	"	"	"	D	2580
"	"	"	"	1.53	"	"	"	"	F	2870
48	12	17	30	1.10	.77	"	"	"	B	2920
"	"	"	"	1.40	"	"	"	"	D	3360
"	"	"	"	1.70	"	"	"	"	F	3790
"	16	"	"	1.10	.90	"	"	"	B	3000
"	"	"	"	1.40	"	"	"	"	D	3420
"	"	"	"	1.70	"	"	"	"	F	3850
54	12	19	33	1.20	.77	"	"	"	B	3870
"	"	"	"	1.54	"	"	"	"	D	4490
"	"	"	"	1.90	"	"	"	"	F	5530
"	16	"	"	1.20	.90	"	"	"	B	3950
"	"	"	"	1.54	"	"	"	"	D	4560
"	"	"	"	1.90	"	"	"	"	F	5580
60	12	21	36	1.30	.77	"	"	"	B	4850
"	"	"	"	1.70	"	"	"	"	D	5740
"	"	"	"	2.10	"	"	"	"	F	7080
"	16	"	"	1.30	.90	"	"	"	B	4930
"	"	"	"	1.70	"	"	"	"	D	5810
"	"	"	"	2.10	"	"	"	"	F	7130

Blow-off Branches with Manholes



Dimensions in Inches							Weight	
Nom. diam.		<i>l</i>	<i>p</i>	<i>n</i>	<i>t</i> ₁	<i>t</i> ₂		Class
<i>e</i>	<i>f</i>							
30	8	17	20	21	.81	.63	B	1880
"	"	"	"	"	1.01	"	D	2040
"	"	"	"	"	1.20	"	F	2190
"	12	"	"	"	.81	.77	B	1940
"	"	"	"	"	1.01	"	D	2100
"	"	"	"	"	1.20	"	F	2250
36	8	"	23	24	.90	.63	B	2270
"	"	"	"	"	1.13	"	D	2500
"	"	"	"	"	1.37	"	F	2740
"	12	"	"	"	.90	.77	B	2340
"	"	"	"	"	1.13	"	D	2560
"	"	"	"	"	1.37	"	F	2800
42	"	"	26	27	1.00	"	B	2850

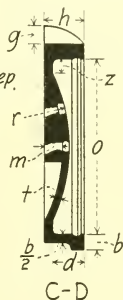
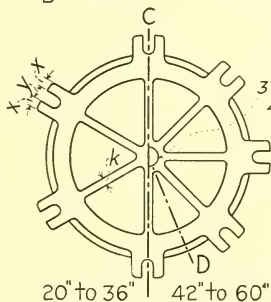
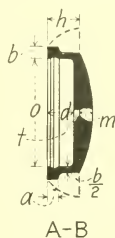
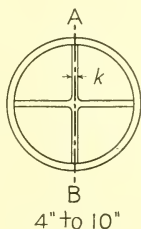
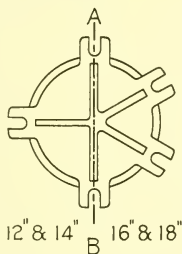
Table No. 10
(concluded)

Blow-off Branches with Manholes

Dimensions in Inches							Weight	
Nom. diam.		<i>L</i>	<i>p</i>	<i>n</i>	<i>t</i> ₁	<i>t</i> ₂		Class
<i>e</i>	<i>f</i>							
42	12	17	26	27	1.27	.77	D	3160
"	"	"	"	"	1.53	"	F	3460
"	16	"	"	"	1.00	.90	B	2930
"	"	"	"	"	1.27	"	D	3220
"	"	"	"	"	1.53	"	F	3520
48	12	"	30	30	1.10	.77	B	3400
"	"	"	"	"	1.40	"	D	3800
"	"	"	"	"	1.70	"	F	4200
"	16	"	"	"	1.10	.90	B	3480
"	"	"	"	"	1.40	"	D	3870
"	"	"	"	"	1.70	"	F	4260
54	12	19	33	33	1.20	.77	B	4330
"	"	"	"	"	1.54	"	D	4920
"	"	"	"	"	1.90	"	F	5920
"	16	"	"	"	1.20	.90	B	4410
"	"	"	"	"	1.54	"	D	4980
"	"	"	"	"	1.90	"	F	5970
60	12	21	36	36	1.30	.77	B	5300
"	"	"	"	"	1.70	"	D	6150
"	"	"	"	"	2.10	"	F	7450
"	16	"	"	"	1.30	.90	B	5380
"	"	"	"	"	1.70	"	D	6220
"	"	"	"	"	2.10	"	F	7500

Caps

Table No. 14



"a" and "b" as tabulated in Table No. 1

$g = 2.50$ " for 12" to 24" incl. $g = 3.00$ " for 30" to 60" incl.

$x = 1.25$ " " " " " $x = 1.50$ " " " " " "

$y = 1.62$ " " " " " " $y = 2.00$ " " " " " "

Dimensions in Inches										Weight
Nom. diam	d	o	h	t	m	k	z	r	Class	
4	3.0	5.7	3.60	.60					K	25
6	"	7.8	3.65	.65					I	40
8	3.5	10.0	4.25	.75					I	60
10	"	12.1	"	"	1.50	.75		16.2	H	80
12	"	14.2	"	"	1.75	"		18.7	"	135
14	"	16.35	4.40	.90	1.90	"		22.4	"	175
16	4.0	18.6	5.00	1.00	2.00	"		27.0	"	240
18	"	20.4	"	"	"	1.00		32.0	D	280
"	"	20.7	"	"	"	"		32.9	F	285

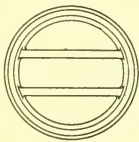
Table No. 14
(concluded)

Caps

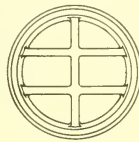
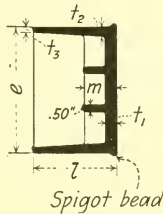
Dimensions in Inches										Weight
Nom. diam	<i>d</i>	<i>o</i>	<i>h</i>	<i>t</i>	<i>m</i>	<i>k</i>	<i>z</i>	<i>r</i>	Class	
20	4.0	22.5	5.00	1.00	3.00	1.00	1.25	18.2	D	330
"	"	23.0	"	"	"	"	1.50	"	F	350
24	"	26.6	5.25	1.05	3.50	"	1.30	23.5	D	450
"	"	27.1	"	"	"	"	1.55	"	F	470
30	4.5	32.6	5.75	1.15	"	1.15	1.30	34.8	B	650
"	"	33.0	"	"	"	"	1.50	"	D	675
"	"	33.4	"	"	"	"	1.70	"	F	700
36	"	38.8	6.00	1.25	4.00	1.25	1.63	44.0	B	940
"	"	39.3	"	1.30	3.95	"	1.88	"	D	970
"	"	39.7	"	1.35	3.90	"	2.08	"	F	1000
42	5.0	45.0	7.00	1.40	4.00	1.40	2.00	63.5	B	1400
"	"	45.5	"	1.50	3.90	"	2.25	"	D	1450
"	"	46.1	"	1.60	3.80	"	2.55	"	F	1520
48	"	51.2	"	1.70	4.00	1.50	2.10	76.5	B	1900
"	"	51.8	"	1.90	3.80	"	2.40	"	D	2000
"	"	52.4	"	2.00	3.70	"	2.70	"	F	2100
54	5.5	57.4	7.50	1.90	4.50	"	2.20	82.0	B	2550
60	"	63.6	"	2.00	"	"	2.30	99.0	B	3100

Table No. 15

Plugs



2 ribs



3 ribs

e = actual outside diam., Table No. 1

Dimensions in Inches								Weight
Norm. diam	l	m	No. of ribs	t_1	t_2	t_3	Class	
4	5.5			.50	.40	.20	K	10
6	"			.60	"	"	I	15
8	"	2.0	2	"	"	"	"	25
10	6.0	"	"	.70	.50	"	H	40
12	"	"	"	.75	"	"	"	55
14	"	"	"	"	"	"	"	65
16	6.5	"	3	"	.60	.30	"	90
18	"	2.50	"	"	"	"	F	110
20	"	2.75	"	1.00	"	"	"	155

Table No. 16

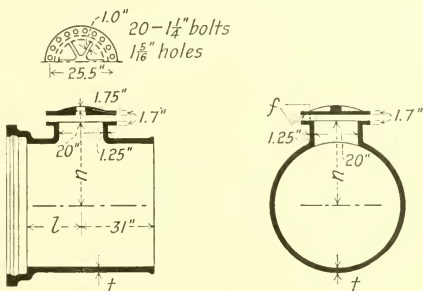
Offsets



Dimensions in Inches								Weight
Nom. diam.	n	s	k	l	r	t	Class	
4	2	10	13.85	35.85	8	.48	K	95
6	"	"	24.25	46.25	14	.54	I	185
8	"	"	26.00	48.00	15	.63	I	290
10	"	"	27.70	49.70	16	.70	H	405
12	"	"	29.45	51.45	17	.77	"	540
14	"	"	31.20	53.20	18	.83	"	700
16	"	"	32.90	54.90	19	.90	"	900

Table No. 17

Manhole Pipes



Dimensions in Inches					Weight	Dimensions in Inches					Weight
Nom. Diam.	L	n	t	Class		Nom. Diam.	L	n	t	Class	
30	17	21	.81	B	1790	48	17	30	1.10	B	3220
"	"	"	1.01	D	2020	"	"	"	1.40	D	3790
"	"	"	1.20	F	2250	"	"	"	1.70	F	4370
36	"	24	.90	B	2190	54	19	33	1.20	B	3980
"	"	"	1.13	D	2520	"	"	"	1.54	D	4750
"	"	"	1.37	F	2850	"	"	"	1.90	F	5760
42	"	27	1.00	B	2680	60	21	36	1.30	B	4800
"	"	"	1.27	D	3130	"	"	"	1.70	D	5840
"	"	"	1.53	F	3570	"	"	"	2.10	F	7120

Note regarding Lugs on Branches

Lugs of the form and dimensions given in the preceding tables are to be placed on the bells of side outlets on all branches, on outlets 12 inches in diameter and larger.

Number and Weight of Lugs on Outlets of different sizes

Diam. of Outlet Ins.	No. of Pairs of Lugs	Wt. of Lugs on one bell. Lbs.	Diam. of Outlet Ins.	No. of Pairs of Lugs	Wt. of Lugs on one bell. Lbs.
12	4	32	36	6	80
14	"	"	42	8	111
16	6	56	48	"	114
18	"	"	54 Class D	"	126
20	"	"	" " F	"	134
24	"	"	60 " D	"	129
30	"	80	" " F	"	137

Two pairs of lugs to be placed on the vertical axis of each bell the others to be spaced at equal distances around the circumference.

If branches are made without lugs the standard weights given in the tables should be reduced in accordance with the weights given above.

PROCEEDINGS.

DECEMBER MEETING.

HOTEL BRUNSWICK, X

BOSTON, MASS., December 10, 1902.

President Frank E. Merrill in the chair; Willard Kent, Secretary.

The following members and guests were present:—

MEMBERS.

Frank A. Andrews, Charles H. Baldwin, Lewis M. Bancroft, Frank A. Barbour, Joseph E. Beals, James F. Bigelow, George F. Chace, E. J. Chadbourne, G. L. Chapin, John C. Chase, William F. Codd, Freeman C. Coffin, R. C. P. Coggeshall, Leonard S. Doten, B. R. Felton, Albert S. Glover, W. J. Goldthwait, E. H. Gowing, John O. Hall, T. G. Hazard, Jr., E. J. Johnson, Willard Kent, George A. Kimball, Theodore H. McKenzie, Henry V. Macksey, William E. Maybury, Frank E. Merrill, Dwight Porter, William B. Sherman, Sidney Smith, George H. Snell, Lucian A. Taylor, William H. Thomas, W. H. Vaughn, Charles K. Walker, George E. Wilde, Frank B. Wilkins, Frederic I. Winslow, George E. Winslow. — 39.

ASSOCIATES.

Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; William V. Briggs; Hersey Mfg. Co., by Albert S. Glover and James A. Tilden; Lamb & Ritchie, by Harry F. Peck; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould and S. F. Ferguson; A. W. Chesterton Co., by W. H. Greenwood; National Meter Co., by Charles H. Baldwin and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Perrin, Seamans & Co., by James C. Campbell; Rensselaer Mfg. Co., by Fred S. Bates; A. P. Smith Mfg. Co., by W. H. Van Winkle; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by J. P. K. Otis; United States Cast Iron Pipe and Foundry Co., by W. B. Franklin. — 19.

GUESTS.

J. J. Moore, Hingham; Edward Atkinson, President Boston Manufacturers Mutual Fire Insurance Co., Boston, Mass.; D. E. Makepeace, Water Commissioner, Attleboro, Mass.; Charles M. Robbins, Chairman Board Park Commissioners, Attleboro, Mass.; William A. Tucker, New Bedford, Mass. — 5.

[Names counted twice — 2.]

The Secretary submitted the following applications for membership, the same having been duly approved by the Executive Committee:—

For Resident Member.

D. E. Makepeace, Water Commissioner, Attleboro, Mass.; W. C. Perkins, Brookline, Mass., Hydraulic Engineer, formerly in charge of water works in Berlin, N. H.; George E. Bolling, Chemist and Bacteriologist in charge of sewage disposal works, Brockton, Mass.; Frank H. Golding, Superintendent Bradford Water and Lighting Company, Bradford, Conn.

For Non-Resident Member.

Alfred Douglass Flinn, Managing Editor, *Engineering Record*, New York City; David J. Howell, Washington, D. C., engaged in preparing plans for new reservoir for Alexandria Water Company, Alexandria, Va.

On motion of Mr. Bancroft, the Secretary was directed to cast one ballot in favor of the applicants, after which they were declared elected to membership.

Edward Atkinson, president of the Boston Manufacturers Mutual Fire Insurance Company, read a paper entitled "The Relation of Water Works Engineers to the Fire Service of Factories." The subject was discussed by Charles K. Walker, of Manchester, N. H.; George H. Snell, of Attleboro; Walter H. Richards, of New London, Conn.; Theodore H. McKenzie, of Southington, Conn.; R. C. P. Coggeshall, of New Bedford; Henry V. Macksey, of Boston; George F. Chace, of Taunton; and John C. Chase, of Derry, N. H. Mr. Atkinson then spoke in reply to criticisms which the discussion had brought out.

Mr. William B. Sherman, of Providence, R. I., gave a talk on "Practical and Theoretical Precision in Everyday Life." Edward Atkinson, of Boston, and Freeman C. Coffin, of Boston, also spoke.

Adjourned.

PROCEEDINGS.

ANNUAL MEETING.

HOTEL BRUNSWICK,
BOSTON, January 14, 1903.

President Merrill in the chair; Willard Kent, Secretary.

The following members and guests were present:—

MEMBERS.

E. W. Bailey, C. H. Baldwin, L. M. Bancroft, J. E. Beals, J. F. Bigelow, J. W. Blackmer, George Bowers, Dexter Brackett, E. C. Brooks, Fred Brooks, A. W. F. Brown, G. A. P. Bucknam, G. F. Chace, J. C. Chase, W. R. Conard, R. C. P. Coggeshall, M. F. Collins, H. A. Cook, F. H. Crandall, J. W. Crawford, A. O. Doane, J. N. Ferguson, A. D. Flinn, Albert S. Glover, J. A. Gould, F. W. Gow, E. H. Gowing, C. E. Haberstroh, J. O. Hall, J. C. Hammond, Jr., G. H. Hart, J. D. Hardy, G. W. Harrington, V. C. Hastings, L. E. Hawes, Allen Hazen, D. A. Heffernan, H. G. Holden, J. William Kay, E. W. Kent, Willard Kent, F. C. Kimball, E. S. Larned, J. W. Locke, T. H. McKenzie, Thomas McKenzie, A. E. Martin, William E. Maybury, F. E. Merrill, H. A. Miller, F. L. Northrop, W. W. Patch, Dwight Porter, C. W. Sherman, J. Waldo Smith, G. H. Snell, G. A. Stacy, J. J. Sullivan, L. A. Taylor, R. J. Thomas, W. H. Thomas, W. H. Vaughn, C. K. Walker, R. S. Weston, F. B. Wilkins, G. E. Winslow, E. T. Wiswall, L. R. Woods.—68.

ASSOCIATES.

Builders Iron Foundry, by F. N. Connet; Chapman Valve Mfg. Co., by Edward F. Hughes; Chas. A. Claflin & Co., by Charles A. Claflin; Coffin Valve Co., by H. L. Weston; William V. Briggs; Eagle Oil & Supply Co., by C. N. Goword; William H. Gallison Co., by H. E. Stilphen; Hersey Mfg. Co., by Albert S. Glover; Henry F. Jenks; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; H. Mueller Mfg. Co., by Fred B. Mueller; National Meter Co., by Charles H. Baldwin and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Rensselaer Mfg. Co., by Fred S. Bates; Ross Valve Co., by William Ross; A. P. Smith Mfg. Co., by Anthony P. Smith; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by F. L. Northrop; Stilwell-Bierce & Smith-Vaile Co., by F. H. Hayes.—21.

GUESTS.

John W. Churchill, Water Commissioner, Plymouth, Mass.; Charles W. Shippee, President Milford Water Co., Milford, Mass.; F. Herbert Snow, Boston, Mass.; Walter T. Littlefield, Somerville, Mass.; S. A. Agnew, Superintendent Scituate Water Works, Scituate, Mass.; Mr. Gregory, Paterson, N. J.; Charles L. Parmelee, New York City; A. H. Robinson, Lowell, Mass. — 8.

(Names counted twice — 3.)

The President appointed Messrs. George E. Winslow and Thomas McKenzie as tellers to count the ballots for officers.

The following new members were elected :—

Resident.

Courtland E. Colver, Groton, Conn., Superintendent Groton Water Co.; Samuel A. Agnew, North Scituate, Superintendent Scituate Water Works; John W. Churchill, Plymouth, Water Commissioner; Fred F. Moore, Civil Engineer Metropolitan Water Works, Boston, Mass.

Non-Resident.

E. H. Foster, New York, Consulting Engineer and Water Works Expert; Percival M. Churchill, Assistant Hydrographer United States Geological Survey, Washington; and William Volkhardt, Superintendent Crystal Water Co., Stapleton, N. Y.

President Frank E. Merrill then delivered the following address :

PRESIDENT MERRILL'S ADDRESS.

Gentlemen of the New England Water Works Association,—Once more time, in its onward flight, has rolled off its cycle of the seasons, and we gather again in our annual meeting to review our accomplishments of the past year and to take up with new life and vigor the duties that lie before us.

The enviable position which we have attained as a professional association will act as an incentive to continued effort on the part of both officers and members to see that there shall be no retrogression.

Harmony and progress go hand in hand; and who shall deny that it is largely due to the absence of discordant elements in our organization that we have been enabled to attain the signal success that is so



FRANK E. MERRILL

President of the New England Water Works Association
1902

unstintingly accorded the New England Water Works Association? I deem it a privilege to pay tribute to the spirit of good-fellowship which has pervaded all our work of the past year, and to express my appreciation of your hearty support and coöperation, factors which are so essential to the successful administration of any officer who aspires to produce results.

The grim reaper has again entered our ranks, and I have to record the death of five of our members, reported since our last meeting.

Mr. William Downey, general foreman of the outside work of the Worcester, Mass., Water Department, died October 1, 1901. He was elected a member of this Association June 14, 1899.

Mr. Cyrus B. Martin, Treasurer of the water company, Norwich, N. Y., died April 2, 1902. Mr. Martin was one of the older members of this Association, having joined on June 17, 1887.

Mr. Joseph C. Hancock, Superintendent of Water Works at Springfield, Mass., for thirty-eight years, died on July 12. Mr. Hancock was one of the original members of our Association. He attended the preliminary meeting held on April 19, 1882, and his membership dates from the founding of the Association, June 21, 1882.

Mr. Frank E. Fuller, an engineer on the Metropolitan Water Works, died August 1, at Santa Cruz, on the far island of Teneriffe, whither he had gone in pursuit of health. Mr. Fuller became a member of our Association March 14, 1900.

Mr. George A. Hotchkin, Superintendent of the Bureau of Water, Rochester, N. Y., died in that city October 6. Mr. Hotchkin had been connected with the Rochester Water Works for many years, and was elected a member of our Association on June 13, 1900.

When emerging from the period of youth into manhood, one naturally, perhaps, becomes retrospective, and we will be pardoned, therefore, as we approach the close of our twenty-first year of associate life, for glancing backward for a moment in review of our growth in numbers and in financial strength. The items which follow have been gathered from the records of the Association, and have been tabulated for the purpose of having them in convenient form for reference in the future:

NEW ENGLAND WATER WORKS ASSOCIATION.

YEAR.	PRESIDENT.	MEMBERSHIP.				ANNUAL CONVENTION.		RECEIPTS.	EXPENDITURES.	CASH BALANCE.
		MEMBERS.	ASSOCIATES.	HONORARY.	TOTAL.	PLACE.	DATE.			
1882	(Organized)	27	—	—	27	Boston, Mass.	June 21, '82	\$	\$7.86	\$ 157.14
1882-3	* James W. Lyon	37	6	—	43	Worcester, Mass.	June 21, '83	\$	171.90	141.38
1883-4	Frank E. Hall	48	9	—	57	Lowell, Mass.	June 19-20, '84		511.44	281.78
1884-5	George A. Ellis	83	44	—	127	Springfield, Mass.	June 18-19, '85		1 643.42	296.86
1885-6	R. C. P. Coggeshall	106	47	—	153	New Bedford, Mass.	June 16-18, '86		1 066.98	572.16
1886-7	* Henry W. Rogers	137	52	2	191	Manchester, N. H.	June 15-17, '87		1 697.15	888.31
1887-8	* Edwin Darling	181	54	3	238	Providence, R. I.	June 13-15, '88		2 127.70	964.68
1888-9	* Hiram Nevins	209	64	4	277	Fall River, Mass.	June 12-14, '89		2 346.65	1 129.30
1889-90	Dexter Brackett	257	73	5	335	Portland, Me.	June 11-13, '90		1 884.78	2 299.65
1890-1	* Albert F. Noyes	281	74	5	360	Hartford, Conn.	June 10-12, '91		3 278.54	1 908.28
1891-2	Horace G. Holden	290	70	5	365	Holyoke, Mass.	June 8-10, '92		3 317.22	2 013.67
1892-3	George F. Chace	338	69	5	412	Worcester, Mass.	June 14-16, '93		3 250.07	1 963.45
1893-4	* Geo. E. Batchelder	365	73	5	443	Boston, Mass.	June 14-16, '94		3 115.99	2 673.03
1894-5	George A. Stacy	401	81	5	487	Burlington, Vt.	Sept. 11-13, '95		3 148.49	2 704.45
1895-6	Desmond Fitzgerald	442	82	5	529	Lynn, Mass.	June 10-12, '96		3 322.94	2 721.74
1896-7	* John C. Haskell	464	80	5	549	Newport, R. I.	Sept. 8-10, '97		3 002.13	2 936.92
1897-8	Willard Kent	488	77	5	570	Portsmouth, N. H.	Sept. 14-16, '98		3 050.23	2 712.40
1898-9	Fayette F. Forbes	494	73	5	572	Syracuse, N. Y.	Sept. 13-15, '99		5 524.65	2 108.24
1899-1900	Byron I. Cook	519	70	5	594	Rutland, Vt.	Sept. 19-20, '00		4 283.22	2 063.57
1901	Frank H. Crandall	493	58	4	555	Portland, Me.	Sept. 18-20, '01		5 158.48	2 541.73
1902	Frank E. Merrill	522	60	5	587	Boston, Mass.	Sept. 10-12, '02			

* Deceased.

From this table it is apparent that the New England Water Works Association is to-day on an eminently satisfactory basis both numerically and financially.

Our membership has shown a healthy growth during the past year. Sixty-six names have been added to our roll, 5 members have died, 14 have resigned, and 15 have been dropped for non-payment of dues; the net increase being 32. The total membership is now 587, and comprises 522 members, 60 associates, and 5 honorary members.

The finances of our Association are in a very satisfactory condition, and the funds continue well guarded by Treasurer Bancroft.

Our receipts have been \$5 158.48 and our expenses have amounted to \$4 680.32, so that, notwithstanding several extraordinary expenditures, our payments have kept well within our receipts and all bills have been paid, so that there are no accounts outstanding against us.

The balance in our treasury at the beginning of the year was \$2 063.57 and at the close we show a balance of \$2 541.73, a gain for the year of \$478.16, or more than twenty-two per cent.

Our present financial standing may be stated as follows:—

<i>Assets.</i>		<i>Liabilities.</i>	
Cash in Treasury	\$2 541.73	Accounts Payable.....	\$0 000.00
Uncollected Advertisements.....	662.50	Excess of Assets over	
Uncollected Dues.....	592.10	Liabilities.....	4 065.86
Sundry Uncollected			
Accounts	19.53		
Office Furniture, value,	250.00		
Total.....	\$4 065.86	Total.....	\$4 065.86

In addition to the above we have an excellent library that is constantly increasing in value.

Details of interest are presented in the reports of the Secretary, Treasurer and Editor, which I commend to your careful attention.

The personnel of our membership continues to be our pride; the interest in our work during the year has suffered no diminution; the attendance at our meetings has been well sustained, and the papers presented have been especially instructive and helpful.

Meetings have been held as follows:—

January 8. Annual meeting at Young's Hotel. Attendance 73.

February 12. Monthly meeting at Young's Hotel. Attendance 106.

March 12. Monthly meeting at Young's Hotel. Attendance 76.

June 25. Annual field day. This meeting was devoted to a most enjoyable excursion down Boston Harbor, by special steamboat, a shore dinner at Nantasket Point Hotel, and a very interesting visit to the works of the Fore River Ship and Engine Company in Quincy. The number participating in this excursion was 174.

September 10, 11, 12. Annual convention in Boston, with headquarters at Hotel Brunswick, Copley Square. Business meetings were held in the morning and afternoon of September 10, with an illustrated lecture in the evening by Mr. Frederic P. Stearns, chief engineer Metropolitan Water Works, on recent progress in the construction of the works under his charge.

On the 11th, meetings were again held in the morning and afternoon, and in the evening Past-President Desmond Fitzgerald entertained a large audience with an illustrated talk on "What an Engineer Saw in Venice." At these sessions interesting papers were presented by other members of the Association, which appear in the pages of the JOURNAL.

On Friday, September 12, an excursion was made to the Metropolitan Water Works, visiting the work in progress in Clinton, Wayland, and Weston. The trip was made especially enjoyable to the 135 members who composed the party through courtesies extended by the Boston & Maine Railroad Company and the Metropolitan Water and Sewerage Board. The registered attendance at the meetings of this convention was 291.

The associate members displayed one of their best and most interesting exhibits of water-works appliances, and rendered valuable assistance in making this a most successful convention.

November 12. Monthly meeting at Hotel Brunswick. Attendance 67.

December 10. Monthly meeting at Hotel Brunswick. Attendance 56.

The December meeting was held during a spell of extremely cold weather, which undoubtedly accounts for the small attendance.

The proceedings of the past year have been signalized by the reports of two committees that have had under consideration matters of much interest in water-works practice. First in importance is

that of the Committee on Standard Specifications for Cast Iron Pipe, and much credit should be awarded this committee for the thoroughness which characterized their consideration of the various matters involved in this question. The results promise to be of great and lasting benefit in the construction of water works through a standardization of pipes and specials.

Next was the report of the Committee on Uniform Statistics. This committee presented a modification of the form heretofore in use for water-works statistics, which met with the approval of this Association, and is likely to be generally adopted by the organizations having an interest in uniformity of municipal statistics.

The committee having under consideration the subject of "Apportionment of Charges for Private Fire Protection and the Means of Controlling the Supply Thereto" is also entitled to honorable mention for their effort to satisfactorily settle several vexed questions. Unfortunately they failed to bring in a unanimous report, and another committee has been formed to give further study to the subject.

It has been stated many times, but will bear repeating, that the object of our Association — namely, the exchange of knowledge pertaining to the construction and management of water works — should appeal to every official, of whatever title, who is responsible in any degree for the proper conduct of a water-works plant. It would be a good investment for every city, town, or company owning water works to be represented, *at its expense*, in the membership of this Association by at least one official; and then it should be seen to that so far as possible he attended the meetings.

A vast amount of good is obtained by the stay-at-home member of our Association through a perusal of the pages of our JOURNAL, but an even greater benefit is derived through the social intercourse and the exchange of ideas afforded by our meetings, the coming into personal contact with the masters of the profession, and the opportunity given here to listen to the words of wisdom born of experience, as they drop from the lips of the many eminent contributors to our valuable and increasing fund of information on water-works topics.

Your Executive Committee has given faithful attention to all the matters that have come before it, and a record of its doings is this year, for the first time, included in the several issues of the JOURNAL. One of the acts of this committee was to renew the lease of the Association headquarters in Tremont Temple for another term of three

years, and I wish to take this opportunity to urge you all to use these finely appointed rooms more freely than has been your custom. There you will find an efficient clerk to give you information, a valuable library for your researches, current magazines, stationery, and like conveniences, with ample room for business appointments or conferences. The privileges are yours, and it is for you to enjoy them.

In reference to our library I will add that we all have an opportunity here to benefit the Association by making such contributions as we can from time to time to the bookshelves.

Our JOURNAL is growing more valuable with each succeeding issue. I may safely say that the December number has not been equalled by any similar publication for the amount of practical and interesting matter within its covers. As the official publication of the foremost organization devoted to the interests of water works, it requires much time and editorial ability to bring it forth in the acceptable form in which it always comes to us, and you will agree with me in recognizing the eminent fitness for this work of our Editor, Mr. Sherman.

The card index which has so long been an object of desire as a complete reference to our JOURNAL contributions is soon to become a materialization, as your Executive Committee has authorized the assistance of expert indexers, who are now engaged in the work.

The value of an Advertising Agent has, I think, been apparent in the results shown by the work of Mr. Thomas. It seems desirable that the JOURNAL should be self-supporting. To accomplish this end, and to maintain the high standard of excellence to which the JOURNAL aspires, it is necessary that much attention be given the advertising department. The results of the past year, showing a net gain of three pages and a total advertising value for the year of \$1 996, are certainly most gratifying. I can only urge that in return you will give to those concerns that favor the Association with their advertising patronage, all of whom are entirely reliable, all the encouragement you can by consulting them relative to such purchases as you may make. I will further suggest your making it known to them that your inquiries result from their advertisement in the JOURNAL.

The duties of Secretary of an organization like our own require the qualities of tact, energy and versatility. The New England Water Works Association always has been fortunate in its choice

of men to fill that position; much of its success, in fact, can be traced to the able services of such men as Coggeshall, Glover, and Whitney, who have honored this office in the past, and to their worthy successor, our present Secretary Kent.

The affairs of our Association appear to be in so altogether satisfactory a condition that there seems little left to be desired, yet it will not do for us to rest content with the success which we have achieved. There are opportunities before us to still further signalize our organization as a leader and authority in matters pertaining to water-works theories and practice. Such problems as conservation and protection of water supplies, equitable charges for water, methods of assessing and collecting water rates, financial relations between the water and other municipal departments, and kindred questions, are live and interesting subjects for your consideration, and if taken up in the meetings of this Association cannot fail to be of value as a record of the prevailing customs and sentiments in different municipalities, even if it is too much to hope that uniformity of policy may result therefrom.

The practical superintendent, the man of experience and ideas, who can tell us how best to lay and maintain a line or a system of water pipes and their various appurtenances, who knows how to straighten out the numerous kinks that are not mentioned in the books but are, nevertheless, so frequently in evidence in the management of a water-works plant, must not be allowed to remain in the background in the proceedings of our meetings; the water registrar, the trained office manager, with his intimate knowledge of water-works accounting and his wide experience with a critical public in matters connected with the monetary end of the business, must be prevailed upon to give up to us the secret of his successful office methods; the engineer and specialist must continue to give us the benefit of their technical training and the results of their researches along lines that appeal to us from a practical water-works standpoint.

The founders of our Association laid their work true to line and grade, and builded well; and now, in this later day, having the suitable material at our hand, it should not be difficult for us to properly dispose it and carry the structure along in a manner that will be a credit to the past, an honor to the present, and an inspiration to the future.

In retiring now, at the close of my term, from the high and honorable position to which you have seen fit to elevate me, a position to which my thoughts will ever turn with pride, I hand over to my successor the duties and burdens of the office, but shall hope to retain indefinitely that confidence which you have reposed in me and the good will and friendly spirit which you have always so generously manifested toward me.

I wish the Association and you individually a happy and prosperous year.

REPORT OF THE SECRETARY.

The Secretary, Mr. Willard Kent, submitted the following report :—

Mr. President and Gentlemen of the New England Water Works Association,—I have the honor to submit the following report of membership, receipts, and disbursements of the New England Water Works Association for the year ending December 31, 1902 :—

MEMBERSHIP.

The total membership of the Association, January 1, 1902 was.....	555
The present membership is.....	587
A net increase during the year of.....	32

The membership is divided as follows :—

MEMBERS.

January 1, 1902. Total Active Membership.....	493
Withdrawals:	
Resignations.....	11
Dropped.....	12
Died.....	5
Transferred	1
	29
	—
	464
Initiations:	
January	4
February	11
March.....	5
June	12
September.....	10
November	9
December	6
	57
Reinstated.....	1
	—

HONORARY MEMBERS

January 1, 1902.	Honorary members	4	
	Addition	1	
		—	5

ASSOCIATES.

January 1, 1902.	Total associate membership.....	58		
	Withdrawals :			
	Resignations	3		
	Dropped.....	3	6	
		—	—	
			52	
	Initiations :			
	January	1		
	February	1		
	September	6	8	60
		—	—	—
January 1, 1903.	Total Membership			587

SUMMARY OF RECEIPTS AND DISBURSEMENTS OF THE NEW ENGLAND
WATER WORKS ASSOCIATION FOR THE YEAR 1902.

RECEIPTS.

Dues	\$2 406.85
Advertising	1 599.00
June excursion	346.00
September excursion	270.00
Initiations	223.00
JOURNALS	211.60
Sundry	32.30
	<hr/>
	\$5 088.75

DISBURSEMENTS.

JOURNAL	\$1 661.69
Rent	400.00
Stationery.....	321.27
Advertising Agent	309.05
Editor	300.00
Assistant Secretary	300.00
Incidental expenses	249.06
September excursion	242.00
June excursion	241.00
Secretary	200.00
Stenographer	141.75

Typewriting machine	\$100.00
Music.....	56.00
Cash	50.00
Stereopticon	48.50
Reprints	43.00
Transportation Agent	17.00
Total.....	\$4 680.32
Amount of Receipts above expenditures	\$408.43 *

At the present time there is due the Association:—

For Dues	\$592.10
For Advertising.....	662.50
For Sundries	19.53
Total.....	\$1 274.13

I know of no outstanding bills against the Association.

Respectfully submitted,

WILLARD KENT,
Secretary.

On motion of Mr. Coggeshall the report of the Secretary was accepted and placed on file.

* The larger figure given in the President's address includes interest on deposits, not received by the Secretary.

REPORT OF THE TREASURER.

Mr. Lewis M. Bancroft, Treasurer, submitted the following report, which, having been duly audited, as shown by the report of the Finance Committee, was received, accepted, and placed on file, on motion of Mr. Stacy.

Oct. 3.	Somerville Journal Co., printing	\$4.50
	W. N. Hughes, printing	8.75
	J. E. Linnehan, Wayland Town Hall	5.00
	H. A. Winship, trunk cover	7.00
	Koss Bros., caterers	125.00
	Thomas P. Taylor, stereopticon	20.00
	Samuel Usher, printing	22.00
	C. A. F. Emery & Son, printing	12.00
	Chambers Printing Co., printing	10.40
	The Whitehead & Hoag Co., badges	28.00
	D. Gillies' Sons, printing	16.75
15.	Hub Engraving Co., plates	7.72
	Willard Kent, salary and expenses to October 1	74.03
	Robert J. Thomas, advertising agent, to October 1	78.45
	Samuel Ward & Co., cash box	2.50
20.	Hobbs & Warren Co., record	2.50
	W. T. Almy, badges	22.00
	J. M. Ham, salary and expenses to October 1	27.65
Nov. 14.	C. A. Noyes & Co., hinge on door	1.40
	Hub Engraving Co., plates	32.08
	Bacon & Burpee, report of September meeting	68.75
28.	D. Gillies' Sons, printing	14.00
	Antonio Amerina, music November meeting	10.00
	J. M. Ham, salary and expenses to November 1	39.90
	Hub Engraving Co., plates	4.69
	Samuel Usher, printing	17.30
	E. L. D. Patterson, report of November meeting	11.25
Dec. 9.	D. Gillies' Sons, printing	4.50
	J. M. Ham, salary and expenses to December 1	30.61
11.	J. M. Ham, salary and expenses to January 1, 1903	25.35
	Robert J. Thomas, salary and expenses to January 1, 1903	78.95
20.	Amerina & Peters, music	10.00
	Il. A. Winship, canvas cover	2.00
	Willard Kent, salary and expenses to January 1, 1903	73.40
24.	Boston Society of Engineers, rent to December 1	100.00
	Charles W. Sherman, salary and expenses to January 1, 1903	87.52
	Hub Engraving Co., plates	37.90
	Wyekeoff, Seamans & Benedict, typewriter	10.00
26.	P. J. McAuliffe, barges	112.00
1903.		
Jan. 2.	Edgar D. Sewall, drawings	39.25
6.	Bacon & Burpee, reporting December meeting	25.50
8.	D. Gillies' Sons, printing	12.40
9.	Samuel Usher, printing December Journal	432.95
		\$4 080.32
	Deposit, People's Savings Bank, Worcester	\$1 345.18
	Deposit, Mechanics' Savings Bank, Reading	1 011.42
	Deposit, First National Bank, Reading	185.13
	Balance on hand	2 541.73
		\$7 222.05

LEWIS M. BANCROFT, Treasurer.

Examined and found correct,

A. W. F. BROWN,

J. W. CRAWFORD,

Finance Committee.

January 14, 1903.

REPORT OF EDITOR OF THE JOURNAL.

Mr. Charles W. Sherman, Editor of the JOURNAL, submitted the following report:—

BOSTON, January 1, 1903.

To the New England Water Works Association,—The Editor of the JOURNAL presents the following as his report for the year 1902:—

The December issue of the JOURNAL contained thirty and one third pages of paid advertisements, of an annual value of \$2 091. A year ago the Advertising Agent reported twenty-seven and one third pages of advertisements, worth \$1 929 per year. The gain is best shown, however, by comparison with the number for December, 1900, which was the last issue preceding the election of an Advertising Agent; that issue contained but \$1 145 worth of advertising in annual value.

Although a material gain in amount of advertising has been made, the receipts for the year from this source have been less than in 1901. The reason for this, and the consequent *apparently* bad financial report exhibited in Tables Nos. 2 and 3, following, is found in the late appearance of the December issue. Ordinarily it would have been out about December 1, but on account of the time required for computing tables of special castings, to accompany the Standard Specifications for Cast Iron Pipes and Special Castings, its appearance was delayed until December 29. This left too little time to send out bills for advertising and get any returns from them before the end of the year.

The accompanying tables show in detail the amount of material in the JOURNAL, the receipts and expenditures, and a comparison with the two preceding volumes.

Without crediting the JOURNAL with any part of the dues paid by members, it will be observed that the expenses incurred on account of the JOURNAL amount to \$622.89 more than the receipts. This is due largely to the failure to send out during the year all the advertising bills properly belonging to 1902, as already explained. It is

also due in part to the unusually large expenses for drafting and engraving, in preparing tables to accompany the reports of the committee on pipe specifications, and in printing advance copies of these reports. It should be noted here that the expense to the Association would have been much greater had not the Metropolitan Water Works assumed the expense of computing the tables of spe-

TABLE NO. 1. — STATEMENT OF MATERIAL IN VOLUME XVI, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1902.

NUMBER.	DATE OF ISSUE.	NUMBER OF PAGES OF								CUTS.
		Papers.	Proceed-ings.	Total Text.	Index, etc.	Adver-tisements.	Covers and Contents.	Inset Plates.	Total.	
1	March	61	23	84	...	32	4	3	123	2
2	June	79	3	82	...	32	4	4	122	8
3	September	77	5	82	...	34	4	8	128	9
4	December	135	20	155	10	34	4	8	211	22
	Total	352	51	403	10	132	16	23	584	41

TABLE NO. 2. — RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XVI, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1902.

RECEIPTS.		EXPENDITURES.	
From Advertisements . .	\$1 599.00	For Printing Journal . .	\$1 297.63
„ Sale of Journals . .	90.60	„ Preparing Illustrations	232.21
„ Sale of Reprints . .	5.50	„ Editor's Salary . . .	300.00
„ Sale of Cuts . . .	1.00	„ Editor's Incidentals .	34.55
„ Subscriptions . . .	121.00	„ Advertising Commis-sions	309.05
	<u>\$1 817.10</u>	„ Reporting	141.75
		„ Reprints and Advance Copies	107.50
Excess of Expenditures .	622.89	„ Statistics Forms . . .	17.30
	<u>\$2 439.99</u>		<u>\$2 439.99</u>

TABLE NO. 3. — COMPARISON BETWEEN VOLUMES XIV, XV (4 NUMBERS), AND XVI, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

	<i>Vol. XIV.</i>	<i>4 numbers of Vol. XV.</i>	<i>Vol. XVI.</i>
Edition (copies)	1 100	1 200	1 200
Average membership	601	586	571
Pages of text.....	345	363	403
Pages of text per 1 000 members....	600	618	707
Total pages, all kinds.....	485	536	584
Total pages per 1 000 members	832	913	1 020
GROSS COST:			
Total	\$1 954.15	\$2 194.26	\$2 439.99
Per page	4.03	4.10	4.18
Per member	3.35	3.75	4.27
Per member per 1 000 pages	6.91	6.99	7.32
Per member per 1 000 pages of text	9.71	10.31	10.60
NET COST:			
Total.....	\$347.55	\$332.90	\$622.89
Per page .....	.72	.62	1.07
Per member .....	.60	.57	1.09
Per member 1 000 pages	1.23	1.06	1.87
Per member per 1 000 pages of text	1.73	1.57	2.71

cial castings, in order to have them more immediately available for their own use. This was done through the coöperation of our members, Frederic P. Stearns, Chief Engineer, and Dexter Brackett, Engineer of the Distribution Department of the Metropolitan Water Works.

The usual fifty reprints of papers have been furnished to their authors without charge. Two hundred reprints of the preliminary report of the committee on pipe specifications were printed as an aid to the committee. The net cost to the Association of these reprints has averaged \$6.30 for each paper reprinted.

The total cost of illustrations for this volume has been \$335.71, or 13.7 per cent. of the gross cost of the JOURNAL. This percentage is large, but results principally from drafting and engraving tables for the pipe specifications.

The present circulation of the JOURNAL is :—

Members (all grades).....	587
Subscribers.....	40

Exchanges are made with twenty-one periodicals.

The custom of sending out three hundred sample copies of each issue has been continued. Originally one number of each volume was sent to every water works in this country and Canada, but a few years ago, in order to comply with new rulings of the Postoffice Department, the present method was adopted. Under this arrangement a copy is sent to every water works in the United States and Canada about once in eighteen months. These sample copies do not seem to result in benefit to the Association at all commensurate with their cost, and it is doubtful whether the advertisers reap any return from this attempt to extend the circulation.

The reprints from the December number of the JOURNAL are not yet ready. The Standard Specifications for Cast-iron Pipe and Special Castings are also being reprinted in pamphlet form; it is the intention to supply whatever demand there may be for these specifications at cost. This work is not yet completed, and of course the bills for it have not yet been presented. A general index to the JOURNAL, from the first number, is now being prepared on cards by the Library Bureau. This card index will be kept at headquarters, and will be kept up to date. It is also the intention to print the index in pamphlet form for distribution to the members.

With the exception of the unfinished work just mentioned, for which bills have not been rendered, I know of no unpaid accounts against the Association on account of the JOURNAL.

Respectfully submitted,

CHARLES W. SHERMAN,

Editor.

On motion of Mr. Holden the report of the Editor was received, accepted, and placed on file.

Mr. A. F. W. Brown, on behalf of the Finance Committee, reported that the committee had examined the accounts of the Secretary and of the Treasurer, and found them correct, correctly footed, and with the proper vouchers.

On motion of Mr. Fuller the report of the Finance Committee was accepted.

THE PRESIDENT. We are honored this afternoon by the presence with us, as our guest, of the chief executive of one of the leading cities of the Commonwealth, and I have the pleasure of introducing

to you at this time his Honor Mayor Grant, of Lawrence. [Applause.]

HON. ALEXANDER L. GRANT. Mr. President and members of the Association, if there is anything I did not expect this afternoon, it was that I should be called upon to make a speech. I am rather young in municipal management, and I cannot tell you gentlemen much about water works or the water department. It seems to me that a great deal of good must come from these meetings and from the exchanging of views and ideas here. I am a student in my city, but I believe that one of the most important departments in the city is its water department and that there are few things more important for the health of the city than a supply of pure water. We have a filtering system that we are told is a fine one, but the capacity of the present filter is not sufficient, as I am informed, and we are now taking up the matter and are going to try to increase its capacity, and I think we can do it under the efficient lead of our water board. I know little or nothing about water-works matters, but I am going to try and learn, and I am going to come down here once in a while, if my friends are good enough to invite me, to meet with you. I am glad to be here this afternoon; I have enjoyed myself very much, and I wish I were better able to talk to you on the subject of water supply. I thank you, gentlemen. [Applause.]

The first paper for the afternoon was by E. H. Gowing, Civil Engineer, Boston, entitled "How I Reduce Pressure on a Gravity System." The subject was discussed by Freeman C. Coffin, Frank L. Fuller, J. Waldo Smith, Edwin C. Brooks, and Dexter Brackett.

ELECTION OF OFFICERS.

Mr. George E. Winslow submitted the following report of the Tellers appointed to canvass ballots for officers for the ensuing year:—

Total number of ballots, 207.

For President.

CHARLES K. WALKER, Manchester, N. H., 203.

For Vice-Presidents.

V. C. HASTINGS, Concord, N. H., 197.

GEORGE P. WESCOTT, Portland, Me., 193.

EDWIN C. BROOKS, Cambridge, Mass., 199.

E. W. KENT, Woonsocket, R. I., 194.

H. N. TURNER, St. Johnsbury, Vt., 193.

J. C. HAMMOND, Jr., Rockville, Conn., 196.

For Secretary.

WILLARD KENT, Narragansett Pier, R. I., 200.

For Treasurer.

L. M. BANCROFT, Reading, Mass., 200.

For Editor.

CHARLES W. SHERMAN, Boston, Mass., 203.

For Advertising Agent.

ROBERT J. THOMAS, Lowell, Mass., 203.

For Additional Members of Executive Committee.

P. KIERAN, Fall River, Mass., 203.

GEORGE A. STACY, Marlboro, Mass., 202.

H. G. HOLDEN, Nashua, N. H., 202.

For Finance Committee.

E. J. CHADBOURNE, Wakefield, Mass., 202.

W. F. CODD, Nantucket, Mass., 203.

A. R. HATHAWAY, Springfield, Mass., 204.

These gentlemen were declared elected. The retiring President, Mr. Merrill, in calling the newly elected President to the chair, spoke as follows:—

Your President-elect needs no introduction to you, gentlemen. He has been in and out of these meetings for many years and has regaled us with his wit and his wisdom so many times that it would be out of place for me to presume to introduce him to you. He was one of those twenty-one men who assembled in a neighboring hotel on the 19th of April, 1882, and on June 21st of that year he assisted in founding the New England Water Works Association. I am sure that he would have filled the office to which he has just been elected many years ago, had it not been for the characteristic New Hampshire modesty which has always been so becoming to him. [Laughter.] I congratulate the Association upon having finally landed him [applause]; and I congratulate you, Mr. President, upon entering upon the duties of your office under such favoring auspices. Gentlemen, I now have the pleasure of presenting to you your President, Charles K. Walker. [Applause.]

President Walker on taking the chair spoke as follows:—

Gentlemen,—I feel very grateful and very thankful for the honor you have conferred upon me. I tell you that I appreciate it, because I know most of the members of this Association, although I do not know them all by name; their faces are familiar to me, and I have shaken hands with them. I am very glad to accept this position to which you have elected me, but still I accept it very reluctantly, because you have had presidents in the past who know as much again as I do, men of ability,—smart men. But I suppose I have been elected because I am an old fellow, about ready to step down and out. [Cries of “No! No!”] I will tell you just exactly how I came to consent to take the nomination. I saw Mr. Hastings, of Concord, coming to my office one day, as I looked out of the window, and I said to myself, “What in the dickens is Hastings doing down here?” He came into the office and I said, “Is there anything I can do for you?” Said he, “I am going to sit right down here with you and stay here until you accept the nomination for President of our Association.” Said I, “You will have a long time to stay, then, for I shall not consent.” Said he, “It’s an honor for a man to be President of this Association.” I said, “I know that, but I prefer to be the chaplain. I want to be chaplain long enough to bury some of my insurance friends.” [Laughter.] I told him I was too old a man, there was no mistake about it; that I could n’t bear the burdens of the office, but he replied, “Why, you are younger than a good

many of those fellows down there who are only forty." Well, that kind of broke me down, and I finally consented.

You must bear with me a little, for I have got to have some help in this business; and I know there are some folks right around me now who are ready to help me. We have among our members some of the smartest men in America, some of the best engineers; and here am I, not an engineer and not much of anything else, so, as I said, it is very reluctantly that I accept the presidency of the Association.

Mr. Leonard Metcalf, of Boston, read a paper, illustrated by the stereopticon, descriptive of the Echo Lake Dam at Milford, Mass.

The President next called upon Mr. F. H. Crandall, Chairman of the Committee on "Apportionment of Charges for Private Fire Protection and the Means of Controlling the Supply thereto," for a report.

MR. CRANDALL. The committee did not expect to be called upon to report at this time. We understand that we were appointed for the purpose of conferring with committees which might be appointed from other associations interested in this same matter, and we have as yet had no opportunity to do that. It will take considerable time for the appointment of these other committees and to arrange for taking the matter up with them. We have not yet received the reprints of the report of the former committee, which we would like to have for use in our work. We have, therefore, simply to report that we have met, and I think we are favorably impressed with each other.

Adjourned.

PROCEEDINGS.

FEBRUARY MEETING.

HOTEL BRUNSWICK,
BOSTON, February 11, 1903.

President Charles K. Walker in the chair; Willard Kent, Secretary.

The following members and guests were in attendance:—

MEMBERS.

S. A. Agnew, C. H. Baldwin, L. M. Bancroft, J. E. Beals, J. W. Blackmer, George Bowers, Dexter Brackett, E. C. Brooks, Fred Brooks, G. A. P. Bucknam, G. F. Chace, E. J. Chadbourne, J. C. Chase, R. L. Cochran, M. F. Collins, H. A. Cook, G. K. Crandall, Lucas Cushing, L. E. Daboll, L. N. Farnum, B. R. Felton, A. P. Folwell, F. F. Forbes, W. E. Foss, A. D. Fuller, J. C. Gilbert, A. S. Glover, F. W. Gow, J. O. Hall, D. A. Harris, L. M. Hastings, T. G. Hazard, Jr., H. G. Holden, H. R. Johnson, D. A. Heffernan, E. W. Kent, Willard Kent, G. A. Kimball, C. F. Knowlton, D. A. Makepeace, A. E. Martin, F. E. Merrill, H. A. Miller, F. L. Northrop, C. E. Riley, W. W. Robertson, C. M. Saville, W. T. Sedgwick, C. W. Sherman, G. T. Staples, G. A. Sanborn, G. H. Snell, G. A. Stacy, L. A. Taylor, R. J. Thomas, H. L. Thomas, D. N. Tower, W. H. Vaughn, C. K. Walker, R. S. Weston, G. E. Wilde, F. B. Wilkins, C.-E. A. Winslow, G. E. Winslow.
— 64.

HONORARY MEMBER.

F. W. Shepperd. — I.

ASSOCIATES.

Ashton Valve Mfg. Co., by C. W. Houghton; Harold L. Bond & Co., by George S. Hedge; Builders Iron Foundry, by F. N. Conne; Chapman Valve Mfg. Co., by E. F. Hughes; Hersey Mfg. Co., by Albert S. Glover and Walter Hersey; Lamb & Ritchie, by Harry F. Peck; Lead Lined Iron Pipe Co., by T. E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; Neptune Meter Co., by Charles H. Baldwin and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Perrin, Seamans & Co., by Charles E. Godfrey; Rensselaer Mfg. Co., by F. S. Bates; A. P. Smith Mfg. Co., by M. G. Millikin and D. F. O'Brien; Union Water Meter Co., by F. L. Northrop. — 17.

GUESTS.

J. P. Wood, Marlboro, Mass.; H. J. Cornegan, General Freight Agent Boston & Philadelphia Steamship Co., Boston, Mass.; Mayor E. S. Horton

and E. B. Hill, Attleboro, Mass.; Mr. Burke, Water Commissioner, Brookline, Mass.; Mr. Donovan and A. H. Robinson, Lawrence, Mass.; John H. Cook, Paterson, N. J.; J. F. Gleason, Quincy, Mass.; J. E. Bunting, H. F. Snow, and J. F. Mallory, Boston, Mass. — 12.

(Names counted twice — 3.)

The Secretary read the following names of applicants for membership, the applications having been approved by the Executive Committee :—

For Resident Members.

Samuel H. McKenzie, Southington, Conn., Superintendent Southington Water Co.; Arthur Truman Safford, Lowell, Mass., Civil and Hydraulic Engineer; Earle B. Phelps, Lawrence, Mass., engaged in the study of filtration of water and sewage and chemical and bacteriological examination of same.

For Non-Resident Members.

Morrell Vrooman, Gloversville, N. Y., City Engineer of Gloversville; George Goodell Earl, New Orleans, La., General Superintendent New Orleans Sewerage and Water Board.

On motion of Mr. Thomas, of Lowell, the Secretary was instructed to cast the ballot of the Association in favor of the applicants; they were declared elected as members.

Mr. Robert Spurr Weston, Chemist and Bacteriologist, Boston, read a paper, illustrated by the stereopticon, on "The Water Supply of New Orleans, La., and its Improvement." Mr. C.-E. A. Winslow, of Boston, and Mr. M. F. Collins, of Lawrence, spoke on topics suggested by the paper.

Mr. Caleb Mills Saville, Division Engineer, Boston, read a paper, illustrated by stereopticon views, on "Pipes and Pipe Laying of the Metropolitan Water Works." Mr. Horace G. Holden, Mr. Dexter Brackett, Mr. George E. Winslow, Mr. Robert L. Cochran, Mr. Frank E. Merrill, and Mr. John H. Cook participated in the discussion which followed the reading of the paper.

The President announced that Past-Presidents Holden and Merrill had been appointed a committee to consider and report upon the place for holding the annual convention in September, and that they would be glad to receive suggestions from any of the members.

Adjourned.

EXECUTIVE COMMITTEE.

The Executive Committee met at headquarters, Tremont Temple, on Wednesday, January 14, 1903, at 11.30 A.M. Present: President F. E. Merrill, Secretary Willard Kent, and Messrs. L. M. Bancroft, C. W. Sherman, E. C. Brooks, C. K. Walker, H. G. Holden, G. A. Stacy, and J. C. Hammond, Jr. Seven applications for membership were approved for recommendation to the Association.

February 11, 1903. — The following were present: President C. K. Walker, Secretary Willard Kent, and Messrs. E. C. Brooks, Edmund W. Kent, George A. Stacy, H. G. Holden, L. M. Bancroft, C. W. Sherman, and R. J. Thomas.

Five applications for membership were considered, and it was voted to recommend them to the Association for ballot.

Past Presidents H. G. Holden and Frank E. Merrill were appointed a committee to investigate and report to the Executive Committee at its next meeting, on a place for holding the next annual convention.

A proposed circular letter, to be sent out with sample copies of the Standard Specifications for Cast-iron Pipes and Special Castings, was read and endorsed.

OBITUARY.

CYRUS B. MARTIN, Treasurer of the Norwich Water Works Company, died at his home in Norwich, N. Y., on April 2, 1902, after a short illness.

Mr. Martin was born in Argyle, N. Y., on September 6, 1830. After attending the academy in that town, he learned the printer's trade, and in 1855 went to Norwich and became joint editor and part owner of the *Chenango Telegraph*. In 1861 he removed to Newburgh, N. Y., where he conducted the *Newburgh Journal* until 1877, when he returned to Norwich. He was president of the Chenango National Bank and of the David Maydole Hammer Company, and director in several other corporations.

He was married in 1858 to Ann Vernetta Maydole, of Norwich, who died in 1885. He is survived by three daughters.

Mr. Martin was elected a member of the New England Water Works Association on June 17, 1887.

BOOK NOTICE.

"Ancient and Modern Engineering and the Isthmian Canal." By William H. Burr, C.E., Professor of Civil Engineering in Columbia University. Svo. xv + 473 pages. Profusely illustrated. New York: John Wiley & Sons. \$3.50 net.

This book is the outgrowth of a series of lectures delivered by the author. It is an admirable review of engineering in general, and gives, in addition to historical notes, a *résumé* of the present best practice in all branches of civil engineering. Part III, devoted to water works, covers 140 pages, into which a very good treatment of the subject has been condensed. The part devoted to the Isthmian Canal is worthy of especial mention, because of the general interest in the subject, and because Professor Burr was a member of the Isthmian Canal Commission.

NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XVII.

June, 1903.

No. 2.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

UNDERGROUND WATER.

SUGGESTIONS ON HOW TO OBTAIN AND CARE FOR IT.

BY GEORGE BOWERS, CITY ENGINEER, LOWELL, MASS.

[Read March 11, 1903.]

When a city or town is obliged to obtain a new public supply of water it generally considers all the lakes, ponds, and rivers in the vicinity before investigating the underground possibilities. This is due, without doubt, to the fact that the amount of available surface water can be readily estimated, while that in the ground is liable to be considered an unknown quantity.

On account of the pollution of the Merrimac River water by sewage from towns outside our state limit, the city of Lowell was obliged in 1891 to obtain a new water supply of ten million gallons per day. In our search for this water we were advised to consider ground water as a last resource only. This at that day was considered good advice, but in the last few years there has been a great change in public opinion. Where, formerly, anything that would run through a pipe was accepted, now the people demand a good, clean, wholesome water, free from objectionable bacteria and practically colorless, a tinge of iron rust from the pipes being considered sufficient ground for complaint. This desire for better water has been recognized in a number of cases by water-works officials, and before long others will be obliged to follow their example.

The conditions necessary to meet this growing demand for purer water may often be met with in ground water, while it is exceedingly difficult to find them in surface water. When a good ground water has been obtained it is much safer water than a sur-

face supply over which a constant guard must be maintained in order to prevent pollution. Ground water is generally stored many feet below the surface, and often has an overlying stratum of practically impervious material. If, then, the water is pumped directly from the ground to the consumer, as is often the case, there is no possibility of any impurities being taken up by it, as it has been exposed to neither air nor light. If instead of this direct supply method the reservoir system is used, the best result is obtained if the reservoir is covered so as to exclude all light, thus preventing any growth of algæ in the water. This is not a difficult thing to do. In fact, in this cement age an old reservoir with sloping sides may be converted into a modern covered reservoir with comparatively little trouble.

One of the advantages of ground water is its uniformity of temperature; being so far below the surface, it is affected by the changing seasons in a comparatively slight degree. In summer it is, of course, much colder than the surface water which is exposed to the sun's heat, making it very desirable for drinking purposes. In winter the surface water is usually near the freezing point, while the underground water remaining at its normal temperature is much above that point, hence not so liable to freeze in the pipes. This last fact is a great consideration, as it makes the whole system much easier to care for during severe winters, an advantage appreciated by water-works superintendents and householders alike.

In searching for ground water as thorough a geological examination as is possible should be made of the territory selected. This must be done in order to determine the position and inclination of the underlying bedrock, and to locate the large deposits of sand and gravel, without which no great amount of water can be obtained.

If the location prove satisfactory to the geologist, test wells should be put down to verify his judgment. In many places where the surface indications might lead him to expect a good amount of water none can be found, as there is no water-bearing stratum below the surface. One great cause of failure to secure ground water is the locating of the wells in places where it is simply convenient, or where they will be near the place to be supplied. If engineers would be governed by the following rule,

they would be more uniformly successful: "Carry your well to the water; don't try to carry the water to your well."

Sometimes a city or town desiring a ground-water supply owns a piece of land from which some water can be obtained, and thinks that it is more economical to use this land than it is to purchase land which would, without doubt, yield them a good supply of water. This is a great mistake in the very beginning, for the price of the land is a very small item to be considered when you take into account the fact that this same land is expected to supply you with water forever. Another source of failure is in making a cheap and inefficient test to ascertain whether or not water can be obtained from the location in question. At this point experience and a thorough knowledge of the subject are greatly needed. When the test wells are driven the material which is brought up to the surface should be thoroughly examined, and by this examination the expert will decide whether or not the place will be able to produce the quantity of water required. Experts, of course, will not always agree, and a location condemned by one will be accepted by another, who will perhaps prove it to be an exceptionally good place.

This point was well illustrated at the very beginning of our work in Lowell. An expert drove a number of wells for us on the desired location, tested them, and pronounced them worthless. Another expert was shown the materials brought up from these wells, and said at once that he was positive that he could obtain a large quantity of water there. He was allowed to make a trial for himself. He drove several wells, and they all yielded an abundant supply, showing that his judgment was correct. Since then we have located a large plant at that place, and for a number of years have pumped from six to eight million gallons per day.

The theory that most engineers adopt and, the speaker believes, adhere to too strictly, is that the amount of ground water obtainable is a certain per cent. of the rain falling upon the visible watershed of such place. When the strata of gravel and sand in which the water is found agree in conformation with the visible watershed, this theory is right, but in reality they are seldom found to agree. The water-bearing material may extend far beyond this visible area, and a much greater supply of water may

be obtained than can be accounted for by their theory. On the other hand, with a less extent of the proper material, less water than was expected will be obtained. But when a place has been found which contains the desired material at the proper depth, and covering a sufficient area, it requires but a short time, in an average season, to determine if the supply will be permanent.

The question of location should be left to the geologist and the expert when possible. When this is decided the engineer's work begins. For one thing, he must see that no sewage is allowed to flow on the land used for the water supply, as any risk of contamination should be avoided. The land may be cultivated if it is thought advisable, but care must be taken in the selection of fertilizers used. After the location has been selected comes the sinking of the wells. The particular kind of well used depends upon the coarseness of the sand or gravel found; if it is fine a screen must be used which has a correspondingly fine mesh, but if the well is sunk in gravel an open end pipe may be used.

To obtain water that is entirely free from sand it is absolutely necessary that the well should be thoroughly made and all the fine sand around the screen removed; then when it is connected with a group and pumped by steam the result should be a perfectly clear water.

A system of wells requires care, as does anything that is expected to produce first-class results. Each well should be provided with a gate by which it may be shut off from the rest, and with a cap so that it may be opened, examined, and cleaned. Every well in use should be opened and thoroughly cleaned at least once a year, and the sand and gravel surrounding the openings or strainers should also be cleaned, and the very fine sand removed. When the well is first opened it should be pumped and the yield per minute recorded; it should then be cleaned, as stated, and pumped until the water is perfectly clear. It should then be tested and the yield taken for the yearly record.

After an experience of ten years the speaker believes that when a well is properly made and rightly cared for it will continue (the conditions being the same) to yield its original amount of water, if indeed it does not exceed it.

You should not place much confidence in people who tell you that they once had some very good wells, but that in a few years

after they were driven the volume of water decreased so much that they were obliged to abandon them. If this matter were looked into carefully it would be found that the wells were simply left to take care of themselves, or else were not properly pumped. As an illustration of this, a small manufacturing company had a good well; it was 2-inch pipe driven fifty feet, and had a few small holes drilled in the side near the bottom, and the bottom left open. For several years the well supplied all the water needed, but as the company prospered and enlarged its business, more water was required, and the engineer was obliged to pump so much from the well that it gradually drew sand and gravel into it, and instead of getting more water, they got less and less, until they gave the well up entirely. Upon investigation the speaker found that the well would yield fifty gallons per minute, but in forcing it beyond its natural capacity and trying to make it a seventy-five-gallon well they ruined it.

Another case has come to the notice of the speaker within a few days. A manufacturing company has a plant consisting of several wells. The company has enlarged its business and must have a greater water supply. On being consulted the speaker suggested that they open their wells and examine them to see if they did not need cleaning. They replied that that would be a very expensive thing to do, as they had built a large storehouse on the land over the wells. They also said that the wells had been giving out for the past few years, and that they did not consider them of much value now, but that they had paid for themselves many times over. This seems poor policy to any one who knows the value of good water and the difficulty of obtaining it.

When pumping, if only a small amount of water is required, the pumps may be run as is most convenient, but if a large amount of water is required, or if you wish to obtain all the water possible, it is better to pump the wells continuously and keep the water in the ground moving towards them than it is to stop pumping, and thus allow the current of water to change its direction.

This former method is the one adopted in Lowell, and we feel well satisfied with the result. The speaker read a paper before this Association five years ago which closed with the following statement: "The quality of the water has from the first been

excellent, and now that the quantity is assured I think we may be entirely satisfied with the result of tube well experiments in Lowell." This statement is as true to-day as it was the day it was made. We have an abundant supply of water, our wells yielding as much as when first driven. This latter fact is, of course, due in a large measure to the care they have received. It goes without saying that they have always been well looked after, as our superintendent, Mr. Thomas, is well known to you all as a man who allows nothing to escape his attention, and who is thoroughly interested in the driven wells, which are entirely under his supervision.

The opinion of the speaker is that if the state would employ a first-class geologist to whom its cities and towns might apply for advice when looking for ground water, it would prevent a great waste of both time and money. The need of a thorough knowledge of the geology of the state is appreciated more and more as the subject of underground water supply is given more attention.

The speaker wishes to call your attention to the fact that but one folio of the United States Geological Survey, showing the areal underground structure, etc., of Massachusetts, has ever been published, and this covers the region about Holyoke only. Another folio nearly completed is the Housatonic quadrangle, which takes in the southwestern part of Massachusetts and a little of New York and Connecticut. If the survey of New England were made and published, it would be a great benefit to us all, and if the members of this Association would interest their representatives to Congress in this matter, there is no doubt but the work in this section of the country might be hastened.

There is probably nothing new in this paper for engineers or superintendents who have had any experience with ground water, but it is written with the hope that it may attract the attention of some users of impure or unsatisfactory water, and cause them to investigate the conditions in their own neighborhood, with the result that they may be added to the ever-increasing ranks of the advocates of ground water.

DISCUSSION.

MR. EDWARD ATKINSON. Mr. President, a claim has been made here for Lowell, against which I wish to enter a caveat.

When it was first proposed in Brookline to take water from the Charles River, I, being a "duffer," made a thorough investigation of the subject and proved conclusively that the Charles River water was unfit to be introduced into Brookline. I then thought it better that we should join with the Metropolitan system and take our water with the rest of the section, and I proved, what was absolutely true, that the Charles River water was totally unfit for use. But the town did n't think I knew much about it, and so they went to work and got their act to take the Charles River water. Now we have water, not from the Charles River, but from the underlying stream which flows through our filter gallery, and we, sir, have the best water in the state. [Laughter.]

MR. A. O. DOANE.* My experience with driven wells was gained while I was in the employ of the city of Newton which, as perhaps a good many of you know, has a system of driven wells along the banks of the Charles River. The plant is not entirely a driven-well system, but it consists of a conduit or a collecting gallery which has wells connected into it. The wells are not pumped on directly, as in Lowell and in Brookline, but they flow naturally by gravity into the conduit, and from there the water goes through a cast-iron pipe under the Charles River to the pump well at the pumping station, so that the water is not taken in the way that is customary with driven wells. For this reason they do not get as much water from the wells as they might if they were pumped from directly, but it has proved very satisfactory so far as the quality of water is concerned; and I think probably there is a less proportion of river water taken in the supply on account of having the driven wells.

The wells are $2\frac{1}{2}$ inches in diameter and were driven in accordance with Mr. Bowers' recommendation, that is, an outlet at the top with cap at surface of ground and a T with branch going into the conduit,—there is a gate on every well; and the system he recommends of cleaning out has been followed, though not perhaps as often as he requires. I think myself that it should be done every year, but it has been practiced nearer once in three or four years. The method of doing it is to put a pump on the end of the outlet, where it reaches the ground; close the branch from the well into the conduit, and pump with a diaphragm pump,

* Division Engineer, Metropolitan Water Works, Boston, Mass.

which will take out all the sand and gravel that is loose. If it proves refractory a wash-boring tool is put in, that is, a drill with a current of water flowing through it, and any material in the well is thoroughly mixed and stirred up with the water from the force pump, and then it is again pumped, and in that way it is possible to bring the well back to its natural flow. There are records of what the wells gave when they were first connected, and they find on pumping them out again and cleaning the wells out that the natural flow is restored.

In connection with this work a modification of the Pitot tube was used to determine the flow of the wells into the conduit when we were not pumping on them, that is to say, the natural flow. It consisted of a Pitot tube having the legs lengthened so it would go down below the branch in the well tube; the air was then exhausted from the U of the tube up above by means of a little vacuum pump (the upper part of the tube being made of glass). This brought the water up into the U so the difference in level could be seen. In this way it is possible to measure the flow of the wells, and it is the only possible way in which it can be done, so far as I know. The tube was first calibrated by testing it on a known flow of water coming up through a tube in the same way that the well flows, the water being actually weighed.

MR. CHARLES N. TAYLOR.* I should like to inquire if it is necessary in a driven-well system to use a vacuum pump? Why I ask about this is that I know of a system of wells that was driven last year for the new Mt. Washington Hotel up at Mt. Pleasant. The engineer on the job was not a New England engineer. A large amount of money was expended in driving the wells. They were driven, I should say, as Mr. Bowers has suggested in every way, and connected up with one main suction pipe, and a large pump of proper design, I presume, attached to it, a permanent pump, and it was started up just before the new hotel opened, but instead of pumping water they pumped air. These wells had been tested with a diaphragm pump, and nearly all of them were found to be fairly good yielding wells. Some of them were not good yielding wells, and they were wells of different depths, but they were all connected on. Finally, the engineer thought that the wells which had n't proved to be very good

* Wellesley, Mass.

had better be shut off, and they had valves and they were shut off, and then they started again, but they still pumped air. The proprietor of the hotel never does things in a half-way manner, and he perhaps suspected that this system would not be satisfactory, and at the same time I had a contract to procure a gravity system for the hotel by going up Mt. Washington and tapping the brook up there and running the water down, so that the hotel was not out of water, for they could use it from the gravity system. But I watched the driven-well system at the same time with a good deal of interest. Another party had the contract for the wells, and they were experimenting with the wells while I was there; and I have since learned that they had continued to experiment with them until they got disgusted, having spent in the neighborhood of \$40 000, and were still pumping nothing but air. The engineer in charge of the work is at a loss to know what to do about it. The contractor tells him he has got to put in a vacuum pump, but he does n't believe it is necessary to do that; and while I am not interested personally in the matter in any way, I have a curiosity to know what the trouble is with those wells, and if I can get any light on it I should like to.

MR. BOWERS. That was the very first thing I had to deal with at the beginning of my experience. The first wells we drove gave us a good deal of trouble on account of air, and people who don't know anything more about it than I did at that time will get into the same difficulty every time. To make a driven well a success it has got to be made perfectly air-tight. The ordinary castings, the ordinary pipe will leak air, so you have got to take each piece of iron separately and test it; everything which is connected with your well plant has got to be tested for air, and if it will stand the test it is all right, but if it will not it is not right. You can put on an air pump and pump the air out, and then you will get some water, but you will have to pump a lot of air unless you take these precautions.

MR. TAYLOR. These wells were driven in very porous soil, coarse gravel. There was an 8-inch casing driven down first and then the 6-inch well-pipe was put in, and the 8-inch one was drawn out; of course that left a little space, and the wells were at different depths. Would that make any difference?

MR. BOWERS. Not at all; that is, if they are 32 feet deep, they are

all right. If they are only 20 feet deep you might get into trouble if you pumped hard.

MR. TAYLOR. In pumping you will pump some of these shallow wells dry and still have water.

MR. BOWERS. Then you ruin your plant right off. As soon as you got one well dry you would be pumping air, and you would n't need to go any further.

MR. TAYLOR. I thought perhaps that was the trouble with this system, that the wells were of so many different depths.

MR. BOWERS. Do you know how deep the shallowest well is?

MR. TAYLOR. No; I don't have in mind just how deep, but they are none of them very deep wells.

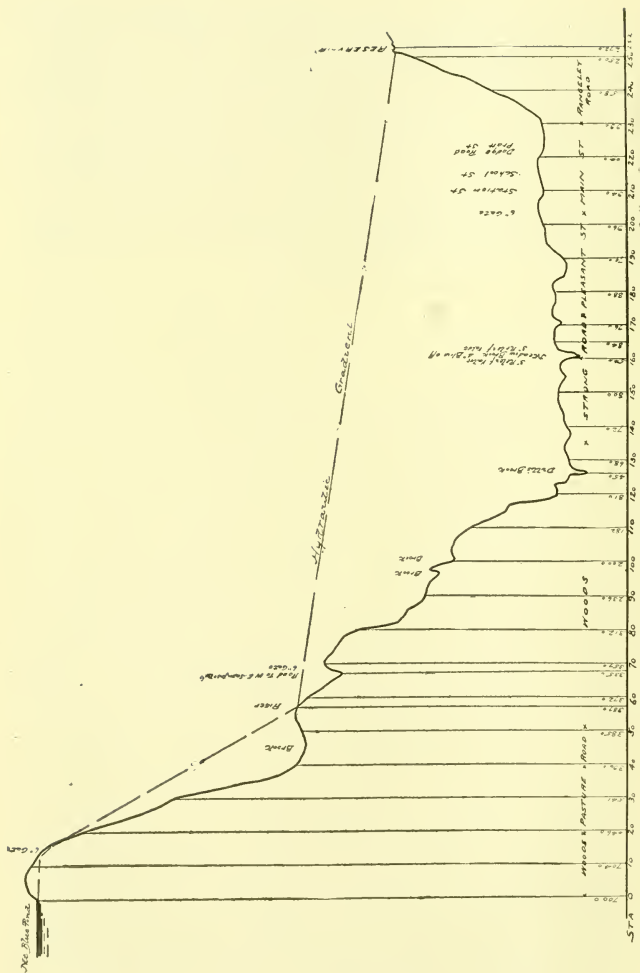
MR. BOWERS. They ought to be below 32 feet; every well ought to be at least 32 feet deep.

MR. DOANE. I should like to ask Mr. Bowers about the form of strainer he has found the best?

MR. BOWERS. If you are going to get your water out of sand you have got to use a strainer. There is no strainer on the market in New England that you can buy; you have got to go to New York or to the West for one or make it yourself. We now make our own. They have a very fine mesh, and every drop of our water comes through a strainer. The New England well-driver does not believe in a strainer. He will put in wells with open ends and holes bored in the pipe. As I said in my paper, we have a piece of land which was tested by a New England well-driver who was considered to be as good a one as there is in New England. He went up and drove test wells over this nice piece of land, we pumped them all, and he said, "There is no water there at all." We got 20 gallons a minute out of one well, but most of them yielded but a few gallons, and some not a drop. The well which was exactly where our station is to-day, from which we can pump eight or ten millions, he could n't get a drop of water out of. It was simply because he stuck to this New England method of an open pipe, nothing to keep the sand out, and the sand would fill it right in at the bottom. Well, a New York man came into the office and he saw a sample of that sand, and he said, "If you will let me go up there I will drive a well within 20 feet of every well that he has driven, and I will give you a good well of water or I won't charge you anything." So

we let him go ahead. I did n't believe he would get a drop of water; I thought the thing had been tested and the test was all right, and that there was no water there. Well, he drove his wells there within 20 feet of these other wells, and he got from 50 to 75 gallons a minute from every one of them; the water rolled right out. He used the New York method, which has a strainer fine enough to just fit the sand, to keep the sand out and separate it from the water; and he put his strainer just where the sand was, not in the quicksand above or below: but he located it just exactly where the sand was; and all our water is got from the sand, and it is pretty fine sand, too.

SKETCH NO. 1.—PROFILE FROM SOURCE TO RESERVOIR.



HOW I REDUCE PRESSURE ON A GRAVITY SYSTEM.

BY E. H. GOWING, C.E., BOSTON, MASS.

[Presented January 14, 1903.]

Mr. President, — I was asked to prepare a paper for the Association, but what I have to say can hardly be called anything more than a talk about a scheme used by me at Phillips, Me., to control the pressure on a gravity system where the source of supply was about six hundred feet above the general level of the village to be supplied.

Sketch No. 1 shows the profile of the force main from the source to and through the town and to the reservoir, which is located at a sufficient elevation and on the other side of the town from the source; sketch No. 2 shows in detail the vertical riser at the reservoir; and No. 3 the vertical riser used between the source and the town at a point shown in Sketch No. 1.

The construction of the vertical riser, which I call a standpipe, is fully shown in the sketches. The Y-branch with outlet looking down is located so that the crotch of the Y is just at the proposed level of the water in the reservoir. To guard against trouble at the reservoir, I also built an overflow pipe into the embankment, the bottom of which is two or three inches above the proposed high-water level of the reservoir.

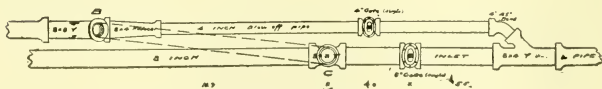
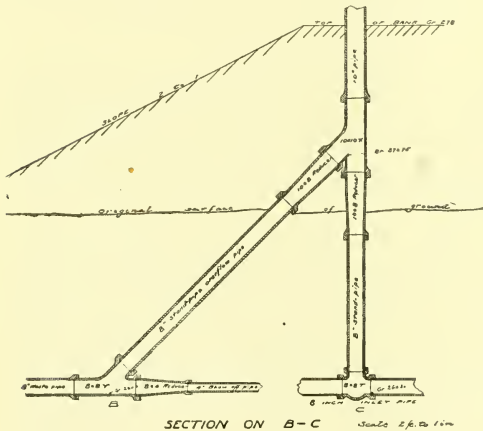
There was plenty of water and to spare in the pond from which the supply came, so it is arranged to have a little more water running than necessary to keep the reservoir full, leaving a small stream running to waste.

The standpipe at the reservoir was not sufficient of itself to reduce the pressure as much as was desirable, so at a point between the pond and the town, shown on the profile, another standpipe was erected. With these two standpipes the pressure was reduced so that at no point in the line was it excessive.

This arrangement is one which could only be used where there was plenty of water, but here there was an ample supply, and it

was arranged at the gate house near the source to have enough water running so that, for our domestic service, the supply was obtained directly from the source, the reservoir being kept full and, as stated, a small amount allowed to run to waste from it.

In case of fire or other exceptional demands for water, the

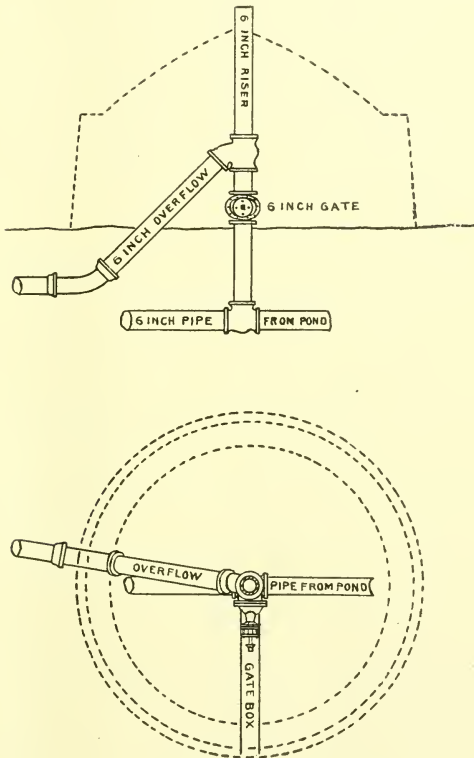


SKETCH NO. 2. — STANDPIPE AT RESERVOIR.

requirements, in excess of what is furnished from the source, are made up from water coming back from the reservoir. The pipe from the source down to the town is 6-inch, and from the reservoir to the town 8-inch; so that if the supply entered the reservoir without going through the town, there would be required at least a 10-inch pipe from the reservoir to the town to give as good service in case of fire. The system is able to throw four streams over any building in the thickly-settled part of the

town, and in some cases five, which gives all the fire protection needed in this town of about fourteen hundred inhabitants.

This arrangement of mine seems to be an automatic appli-



SKETCH NO. 3.—STANDPIPE BETWEEN SOURCE AND THE TOWN.

ance, which is absolutely reliable and needs no looking after. I have known of pressure-reducing valves being used for similar service, but I never saw an automatic machine of any kind

which I did not think needed more or less looking after, and they are apt to give out just at the time when wanted the most. These standpipes have given us no trouble, and I do not see how they can possibly do so.

This town is situated where the frost may go quite deep, and it was arranged to have the Y's buried so deeply as to be below the reach of frost. The pipe and Y's are so large that I can see no possibility of their being obstructed by anything which can go through the screens used at the source.

I have had occasion to use similar appliances in four other water-works systems, and have never heard of their giving any trouble at all.

DISCUSSION.

MR. FREEMAN C. COFFIN.* I think Mr. Gowing is to be congratulated on having plenty of water to work this device. It seems to be rather more efficient than economical of water. [Laughter.] It strikes me it is a very good thing in a place, as he says, where there is plenty of water to waste; but certainly when the draft is small the overflow or waste water must be considerable. This subject of excessive head sometimes presents quite a problem. I had similar conditions in Proctor, Vt., where there was a head of about four hundred feet, the initial head, on a gravity system. There, unfortunately, although I supposed there was no water to waste, it has proven since that there was not quite enough to use. [Laughter.] I put in a pressure-reducing valve, and I shall have to corroborate to a certain extent what Mr. Gowing says about pressure-reducing valves, judging from my experience there. There is in Proctor, however, a very efficient device in the overflow of the standpipe: the flow of water to the standpipe is regulated by a gate, which is so set that the rise and fall of water in the standpipe throughout the day compensates for the differences between the rate of flow and the rate of draft. If it does n't do that completely the standpipe overflows and water is wasted. But the experience has been that there has not been a great deal of water wasted in that way. I do not know whether there is any really reliable pressure-reducing valve or not. It is something to be de-

* Civil Engineer, Boston, Mass.

sired, and it would fill a long-felt want if there were a really good pressure-reducing valve that would n't need constant attention.

MR. FRANK L. FULLER.* I would like to ask Mr. Gowing if I understood him correctly that there was a pipe from this pond directly to the village, independent of the pipe from the pond to the reservoir?

MR. GOWING. I do not know as the sketches show that exactly, but the arrangement is that there is one pipe from the pond to and through village and to the reservoir. The first stand-pipe for reducing pressure is part way down, between the town and the village, and the other one is at the reservoir. There is also an overflow running through the reservoir embankment, in case the standpipe should be obstructed in any way. There is more likelihood of ice and snow in winter obstructing the overflow than of anything obstructing the standpipe.

MR. J. WALDO SMITH.† There has been a good deal said this afternoon about reducing valves which do not work. Now, I would like to give my testimony about such valves that do work. I have had occasion during the past ten years to use a great number of reducing valves of from 4 inches to 16 inches in size, about fifty in all, I think, and all of these valves have worked. Some of them have been set where the conditions were exceedingly trying. They have all been in a position where their action could be watched, and any variations shown on recording gages, and I have found in all cases that they have worked satisfactorily; like all other automatic machines, they need attention, but if they are properly taken care of I have great faith that their performance will be satisfactory.

MR. EDWIN C. BROOKS.‡ I feel that I ought to add my testimony here to the efficiency of these reducing valves. We have two, 16-inch, which have been in use about six years, and have not given one particle of trouble. We have recording gages in different parts of the city, and I think the record of those gages will show that these valves have done their work in a manner which leaves nothing to be desired. They absolutely

* Civil Engineer, Boston, Mass.

† Engineer and Superintendent, East Jersey Water Co.

‡ Superintendent, Cambridge (Mass.) Water Works.

take care of the pressure during the night within two feet static head, and all through the day the pressure on any of these gages will scarcely ever vary to exceed eight to ten feet during the periods of greatest consumption.

MR. GOWING. I do not wish to be understood as condemning all pressure-reducing valves, as doubtless there are some which will do good work. The conditions in the places where I have used this scheme are different from those usually met with, as will be understood when I say that the amount charged up last year on this particular water-works system for salary, expense, and everything concerned in the maintenance of the works was \$185, \$50 of which was for car-fares and traveling expenses. It will be understood that these works had to run alone, and get along without very much supervision. When there is plenty of water to waste, and it is advisable to curtail the expenses of supervision, it seems to me that something of this sort is useful.

MR. COFFIN. There are a number of pressure-reducing valves on the Metropolitan system, and perhaps Mr. Brackett can tell us something about them.

MR. DEXTER BRACKETT.* I do not know that I can say very much on this subject except to state that there are in use on the Metropolitan works five pressure-reducing valves, three of which are under our direct supervision. I think I may say that these valves are similar to other automatic machines in that they will sometimes get out of order. One of our valves has given us practically no trouble, while another of the same size, used, so far as we can judge, under exactly the same conditions, has given considerable trouble. The pressure runs up on the delivery side of the valve higher than it should at some times. Trouble is liable to occur where these valves are used for controlling the elevation of water in a standpipe if an attempt is made to control the elevation of the water within a few feet. Where the valve is used for supplying into a closed service a variation of three or four pounds makes no difference, and the valve works satisfactorily. If the pressure varies as much as eight or ten pounds it is not likely to be noticed. On the other hand, if the valve is controlling the supply into a standpipe, and it is desired to keep the water within about five feet of the top, and

* Engineer, Distribution Department, Metropolitan Water Works, Boston, Mass.

anything goes wrong with the valve, you hear from it very quickly. In cases where the pressure on the supply side of the valve varies considerably the results are not as satisfactory, as we find that under this condition the pressure on the delivery side of the valve does not remain constant. On the whole, the valves give satisfaction, and we have no desire to take them out. If you expect, however, that they will work without any attention being given to them, I should say you would be disappointed.

The thought comes to me in connection with Mr. Gowing's scheme, that a pressure-reducing valve placed on the pipe line just above the standpipe would have the effect of saving water, which might be desirable, and at the same time would prevent any undue pressure on the pipe line in case the valve failed to control the pressure.

MR. ROBERT J. THOMAS.* Before closing on this matter of pressure-reducing valves, I would simply say that any of you gentlemen who intend purchasing such valves can, by consulting the advertising pages of the JOURNAL, obtain a valve which will not give any trouble. [Laughter and applause.]

MR. FULLER. When the high service was put in at Arlington one of Mr. Ross' 5-inch valves, I think, was used. That was put in four or five years ago, and I have never heard that it has not worked satisfactorily. It was placed in the lower end of the town, where the pressure was very heavy, and so far as I know it has worked well.

* Advertising Agent, New England Water Works Association.

THE ECHO LAKE DAM, AT MILFORD, MASS.

BY LEONARD METCALF, CIVIL ENGINEER, BOSTON, MASS.

[Read January 14, 1903.]

About twelve miles southwest of South Framingham, Mass., lies the town of Milford, on the headwaters of the Charles River, and adjoining it the town of Hopedale. Both of these towns are supplied with water from the Charles River by the Milford Water Company, which was incorporated under Act of the Massachusetts Legislature in the year 1881. The joint population of the towns is shown by the following table:

POPULATION ACCORDING TO U. S. CENSUS.

Year.	Milford.	Hopedale.*	Total.
1880	9 310	.....	9 310
1890	8 780	1 176	9 956
1900	11 376	2 087	13 463

The water consumption has averaged during the last decade from 50 to 60 gallons per capita, as shown in greater detail by the accompanying table:

Year.	TOTAL ANNUAL CONSUMPTION. In U. S. Gallons.	AVERAGE DAILY CONSUMPTION.	
		Total Gallons.	Gallons per Capita.
1895	192 300 000	527 000	51
1896	234 400 000	642 000	60
1897	221 300 000	606 000	55
1898	204 200 000	559 000	48
1899	243 700 000	668 000	54
1900	310 500 000	851 000	63
1901	261 300 000	716 000	49
1902	288 800 000	791 000	51

The small per capita consumption is remarkable in view of the heavy pressure prevailing in certain parts of the town, the territory covered, and the nature of the service, — a direct pumping or so-called "Holly" system.

* The town of Hopedale was incorporated and set apart from Milford, April 7, 1886.

Analysis indicates that the present normal consumption is about 275 000 000 gallons per year, or approximately 750 000 gallons per 24 hours, and that during the summer months this amount is materially exceeded, reaching an average daily consumption of upwards of 1 000 000 gallons per 24 hours, with maximum rates of consumption of more than double this amount for short periods.

The water supply is drawn from three deep wells, the first 19 feet in internal diameter by 26 feet in depth; the second 14.5 feet in internal diameter by 25 feet in depth; the third 22 feet in internal diameter by 28 feet in depth — all yielding ground water, and from two uncovered slow sand filters, the first 0.21 acre in area, the second 0.24 of an acre in area; and from two new covered masonry slow sand filters, just completed, each of approximately one-eighth of an acre (0.130 and 0.131 acre).

The sand filters draft water from the Charles River, and discharge it after filtration into the first well, which under the recent changes has been converted into a pump well, with suitable provision for still using it when desired as a supply well. It is estimated that during the normal summer season the wells yield about 300 000 gallons per day, the rest of the water consumed being furnished by the filters.

Though not essential here, it may be of interest to state that the pumping plant (a "Holly" system) consists of three pumps — a 3 000 000-gallon "Holly" fly wheel, compound condensing pump; a 2 000 000-gallon Worthington duplex direct-acting, compound condensing pump; and a 750 000-gallon Knowles duplex direct-acting, compound condensing pump.

Analyses of the water made from time to time by the Massachusetts State Board of Health show it to be of good quality. While the number of persons per square mile of watershed is very low, the presence of certain swamp areas above the pumping station, and the possibility of contamination by the employees of the various quarries located upon the watershed near the river, made it advisable from the liberal point of view of the water company to filter the water, in order to remove all possible chance of infection and the organic matter present at certain seasons of the year, and to reduce the color of the water.

From original plans in the possession of the Massachusetts

Topographical Survey Commission,—now merged with the Harbor and Land Commission,—through the courtesy of its engineer, Mr. Henry B. Wood, a tracing was made of the vicinity of Hayden Row, Hopkinton and Milford (Mass.), from which has been determined the watershed tributary to Echo Lake above the dam, and at the pumping station of the Milford Water Company. From this plan and surveys made for the Milford Water Company, the following data were determined:

Watershed tributary to Echo Lake, including water surface, 1.53 square miles.

Watershed tributary to pumping station pond, exclusive of Echo Lake watershed, 2.10 square miles.

Total area of watershed above pumping station pond, 3.63 square miles.

Area of Echo Lake water surface to crest of old dam, 70.56 acres.

The phenomenally dry summer of 1900 threatened a shortage of water, and made it necessary for the water company to take steps toward increasing the future capacity of its water supply. The situation was therefore carefully examined, and it was determined to further develop the present sources of supply by increasing the storage capacity, and hence the yield of the tributary watershed at the pumping station. The most available means for accomplishing this proved to be by raising the Echo Lake dam, located in Hopkinton near the Milford line, on the headwaters of the Charles River; while but 1.53 square miles of the total 3.63 square miles of watershed above the pumping station was tributary to Echo Lake, the opportunity for economically impounding the storm waters there was most unusual. The slopes of the lake shore were steep and rocky on all except the upper reaches of the pond; the amount of masonry required was comparatively small, and plenty of good granite in ledge and boulders was right at hand. Moreover, the raising of the dam resulted in increasing the mean depth of the lake without seriously increasing the area of shallow flowage; while the construction of a storage basin at any other site available would have very materially increased the area of shallow flowage. Computations based upon the Sudbury River records indicate that the mean yield of the Echo Lake watershed, over a long period of years,

would probably be about 550 000 000 gallons per annum, amounting (with a mean storage capacity of 175 000 000 gallons) to 1 500 000 gallons per 24 hours; and that in the driest year this might amount to as little as 250 000 000 gallons per annum, or 700 000 gallons per 24 hours. Investigation indicated the wisdom of raising the flow line at least 5 feet, which, bearing in mind the effect of a succession of dry years, was estimated to make possible an average daily yield, with a storage capacity of from 160 000 000 to 240 000 000 gallons, of from 900 000 to 1 000 000 gallons of water, involving a fluctuation in the lake level of from 6 to 11 feet; and in extreme cases, periods of nearly a year when the water would not fill the lake to the crest of the dam. As it was found, however, that these developments required the purchase of additional lands for flowage purposes, it was deemed expedient to increase slightly the amount of land to be bought or condemned about the lake, in order to enable the water company to control the entire watershed surrounding or contiguous to the lake. This was therefore done, and plans were drawn for raising the dam 10 feet and the flow line $9\frac{1}{2}$ feet. This construction developed the following flowage areas and storage capacities:

ECHO LAKE STORAGE CAPACITY.

MILFORD WATER CO., MILFORD, MASS.

Area of tributary watershed above dam, estimated from the Massachusetts Topographical Survey Maps 1 53 square miles.
 Crest of wasteway of new dam at gr. 109 5 (assumed bench).
 Crest of new dam „ 110 00
 Crest of old dam and wasteway, approximate „ 100 00

AREAS AND STORAGE CAPACITIES (AFTER SURVEYS BY L. M.)

Grades.	Areas, acres.	Capacities, gallons.
110 0	111 5	162 300 000
105 0	87 8	128 400 000
100 0	70 0	103 100 000
95 0	56 6	

The storage capacity between gr. 109.5, crest of wasteway, and gr. 110, crest of dam, is approximately 19 000 000 gallons, which is equivalent to $\frac{3}{4}$ inch rainfall over the entire watershed above the dam.

STORAGE CAPACITY IN 1-FOOT LAYERS BELOW TOP OF WASTEWAY.

Distance below Crest of Wasteway. Feet.	Volume between Crest of Wasteway and given Level below Crest. Gallons.	Volume in 1 foot of Depth above given Level. Gallons.
1	35 000 000	35 000 000
2	68 000 000	33 000 000
3	100 000 000	32 000 000
4	130 000 000	30 000 000
5	159 000 000	29 000 000
6	186 000 000	27 000 000
7	212 500 000	26 500 000
8	238 000 000	25 500 000
9	262 000 000	24 000 000
10	285 000 000	23 000 000
11	306 500 000	21 500 000
12	327 000 000	20 500 000
13	347 000 000	20 000 000
14	366 000 000	19 000 000
15	384 000 000	18 000 000

While the section of the old dam — which was of the arched form, upon a radius of about 90 feet, with a maximum height in the center of 26 feet, 19 feet base, and 5 feet horizontal crest, with vertical up-stream face, and down-stream face with a batter of 1 in $1\frac{3}{4}$ — indicated the possibility of increasing its height without further reinforcement, the uncertainty as to the character of its foundation and the very serious damage that would have resulted from a breach in the masonry, or from the undermining of its foundation, owing to the increase in the head or the the pressure of water upon it, made it necessary to determine the character of its foundation. Inquiry unfortunately developed but little definite information, and that to the effect that “the

dam was founded on rock, except for a distance of about 30 feet " (actually 48 to 60 feet) "in the center of the valley, where it was carried down into impervious hard pan for a depth of about 4 feet, the gate being but about 6 feet above the bottom of the dam, and about 2 feet above ground level; and that two thirds of the masonry was laid in Rosendale cement mortar, the remaining third in Portland cement mortar."

The work, therefore, was postponed till the latter part of the summer, when test pits were dug below the dam at the lowest points in the valley. One of these pits disclosed a footing of disintegrated granite; the second of very fine sand; the third of hard pan, underlaid with loose ledge. Plans were therefore drawn for reinforcing and partially underpinning the old dam, and the water in the lake was drawn down in September from 7 to 8 feet below the crest of the dam. This gave opportunity for the construction of a coffer dam at the narrows about 175 feet above the dam to hold back the waters of the lake during the undermining of the old structure, and thus to relieve the pressure of the water upon it. A coffer dam was built from an outcropping ledge near the center of the narrows to the easterly shore, of white pine logs, cut from the new flowage area near at hand, faced with plank and filled and reinforced with material from a borrow pit excavated in a neighboring bank. The gap on the westerly side of the ledge was stopped with sand bags. The area below this coffer dam was then drained through the 24-inch blow-off gate, discharging into a wooden flume and carrying the water clear of the excavation below the main dam.

The section first proposed for the new dam involved a maximum height of 41 feet, base 32 feet, crest 6 feet, up-stream face vertical except near the crest, where a triangle was to be cut off to reduce ice pressure, and the down-stream face with the following batters: For 12 feet down from the top, a batter of 1 in 6; then for 10 feet, 1 in 2; and below this, 1 in 1. The varying section of the old dam and the thin shell of masonry which would have resulted, at certain points, from the use of the proposed section, led to the adoption of the somewhat simplified section shown; that is, with a vertical up-stream face, 6 feet crest (with 2 feet taken out to give suitable batter to reduce ice pressure), a down-stream face with a batter of 1 in 6 for 10 feet, and 1 in $1\frac{1}{2}$

below this point, giving a maximum theoretical section of 29.4 feet (actual 32.5) on the base for the maximum height of 42.5 feet. (See Fig. 1.)

The excavation was then begun and carried down to solid granite ledge, the rotten stone being removed by picks, and blasting with black powder in small charges. In this way the dam was undermined about $7\frac{1}{2}$ feet in depth and for a distance of about 3 feet up stream (or underneath the dam) from the downstream face of the old masonry. (See Plates I and II.)

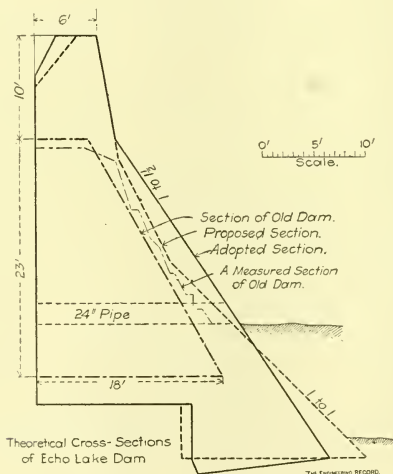
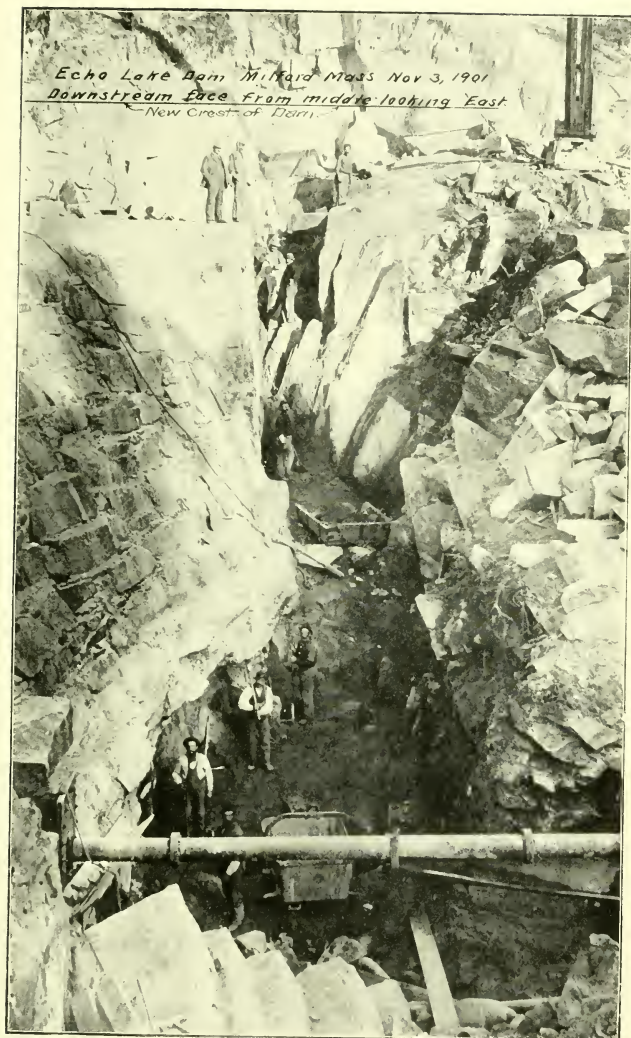
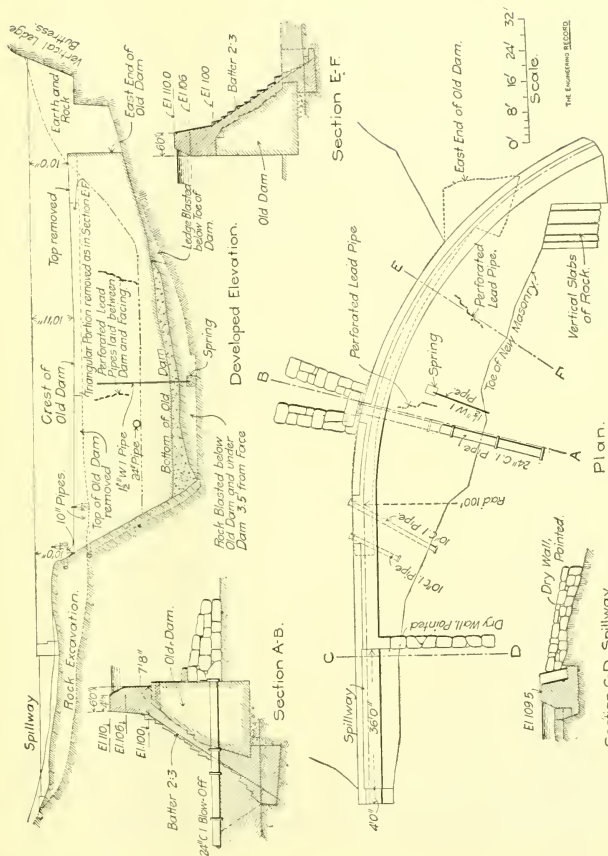


FIG. 1.

It is perhaps interesting to note that at the westerly end of the sub-foundation, lying against the nearly vertical face of the ledge or side wall of the valley, was found a vein or dike of schistose material, occurring in much the same way as the dike in the center of the valley under the new Wachusett dam of the Metropolitan Water Works. While this material did not appear to have carried any water, it could be easily excavated with a pick. The material under the main body of the old dam in the center of the valley for a distance of about 48 to 60 feet was a good, dense







Plan.

FIG. 2.

Section C-D. Spillway

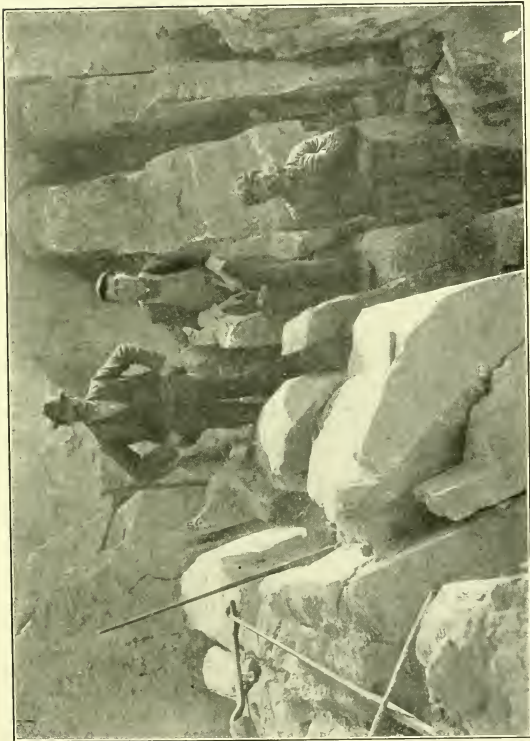
hard-pan, partially underlaid with a layer of free sand and gravel. The westerly shoulder of the dam abutted upon a hard though somewhat seamy ledge; but the easterly end was found to have been built against the hard earth filling and vertical slabs of granite. (Plate III.) All loose material was removed to hard rock. A suitably rough inclined footing was blasted out of the ledge in the bottom of the valley; a trench or shoulder was cut well into the ledge on the westerly side, for a skewback for the dam arch, while the easterly end of the dam was abutted against an ideal ledge skewback or buttress of hard granite, with vertical face, normal to the thrust of the arch, which was disclosed by the excavation of the granite slabs and loose material previously referred to.

In this excavation the masonry was laid of split granite rubble, in Portland cement mortar mixed with one part of cement to two parts of sand by volume. The granite was quarried mainly on the easterly side of the valley, from outcropping ledges and large boulders, by means of plugs and feathers and occasional charges of black powder. The rock was handled by a derrick, lifting it from the quarry to the dam, the work upon the latter being handled by two derricks located on top and at the ends of the dam, shifted in position two or three times during the progress of the work.

By a small amount of earth stripping and blasting of ledge, a spillway was built clear and free from the main portion of the dam, the water flowing over this being deflected by means of a short dry wall over the natural rock surface in a waterfall or cascade into the valley at a point about fifty feet below the main structure. Owing to the topography of this westerly hillside, it was necessary to locate this spillway on a tangent to the main portion of the dam which spans the gorge, and for this reason the latter was reinforced at its junction with the side walls of the valley, and very carefully bonded into the solid ledge. (See Fig. 2.)

While the water was drawn off below the coffer dam, the opportunity was taken for cutting out and repointing the up-stream face of the old masonry, and for carefully grouting with Portland cement mortar under a head the three or four voids or holes that were found in the masonry. All of this pointing was done with a one-to-one mixture of Atlas Portland cement.

PLATE III.



Two points in the method of construction adopted involved serious consideration: First, the possibility of an upward pressure over a considerable area of the foundation or bottom of the old dam, owing to the fact that it was not founded upon ledge; and, second, the possibility of a bursting pressure between the old and new layers of masonry, owing to leakage of the old structure and the practical impossibility of obtaining a perfect bond between the old and new walls. Both the old and the new sections of the dam were designed as gravity sections, without allowance for the additional stability afforded by the arched form, and it will be seen from the accompanying diagram that even with an upward pressure over a portion of the footing of the old dam the line of resistance would fall well within the new base. As an additional precaution, however, a small, dry well was left underneath the dam just up-stream from the new masonry, with a $1\frac{1}{2}$ -inch wrought-iron pipe passing through the masonry and discharging freely down stream. This well was located at a point where a spring was found coming up through a seam in the ledge, and measurements were made of the amount of water percolating through the pipe. Since the completion of the work the flow of water through this pipe has been observed from time to time, but no evidence of increased seepage or leakage has been found. Several springs of this sort were encountered in laying the footing masonry, but their origin appeared to be in the nature of ground water from the hillside above, rather than from the lake itself.

As regards the bonding of the two layers of masonry, it should be noted that the foundation was exceedingly well bonded into the footing ledge, and that it is further assisted by the thrust of the dam under pressure of the water; that both ends or sides of the dam abutting upon the slopes of the valley were reinforced and unusually well bonded into the ledge, and that a portion of the top of the old dam was removed, and the new work was bonded into and over the old masonry. Moreover, the effect of the arch is probably to bring the old and the new faces of the masonry tightly in contact. As an additional precaution, however, two perforated 1-inch lead pipes were laid against the downstream face of the old structure, following vertically said face, and built into the new masonry, so that in case of the develop-

ment, through leakage or other cause, of a considerable area of hydraulic pressure between the two layers of masonry, this seepage or leakage water may be drained out by these pipes before it can develop large areas of such stresses. Up to this time no leakage has been apparent in these pipes, but the fact should not be overlooked that the lake has not yet had opportunity to fill to the new flow line.

As already briefly alluded to, a triangle of masonry is cut off on the up-stream face (2 feet on the crest and 4 feet vertically down), giving a batter to the face of 1 in 2, in order to reduce the danger from ice pressure; and the bottom is sloped by paving with large granite blocks at and near the spillway for the same reason.

After completion the crest of the dam was cut and dressed to line with hammer and pointed, and all joints were pointed with one to one Portland cement mortar.

Two 10-inch blow-off gates are provided, located at 8 and 14 feet respectively below the flow line.

It was thought inexpedient to strip the new flowage area, owing to the expense involved and the character of the stream between the dam and the pumping station, particularly in view of the fact that the water is all filtered through slow sand filters before use. The area was therefore merely cleared with ax and brush hook.

The quantities of masonry involved and the items of cost are not here given, for the reason that the work was of such special nature as to make such figures of little value for purpose of estimating elsewhere, without a very intimate knowledge of all the local conditions, some of which were quite unusual. It may be of interest to note, however, that the cement used amounted to 0.83 of a barrel per cubic yard of masonry (which is equivalent to 1.2 cubic yards of masonry per barrel of cement), based upon the entire work, including all foundation work, pointing, grouting, etc.; while the rubble masonry itself required in the mass work about 0.7 barrels of cement per cubic yard of masonry.

The speaker takes pleasure in acknowledging his indebtedness for hearty coöperation and assistance to Mr. J. William Kay, Superintendent of the Milford Water Company; to Mr. A. T. Safford, Consulting Engineer, of Lowell; and to Mr. William T. Barnes, Resident Engineer on the work.

PLATE IV.

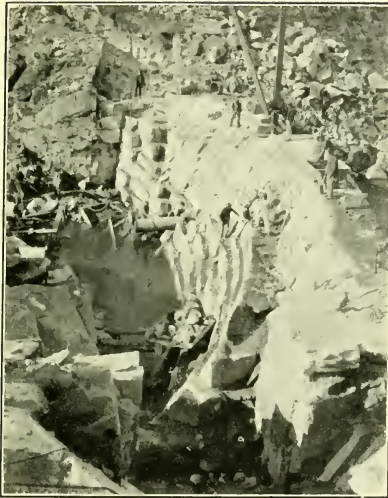


FIG. 1. — REINFORCING OLD DAM.

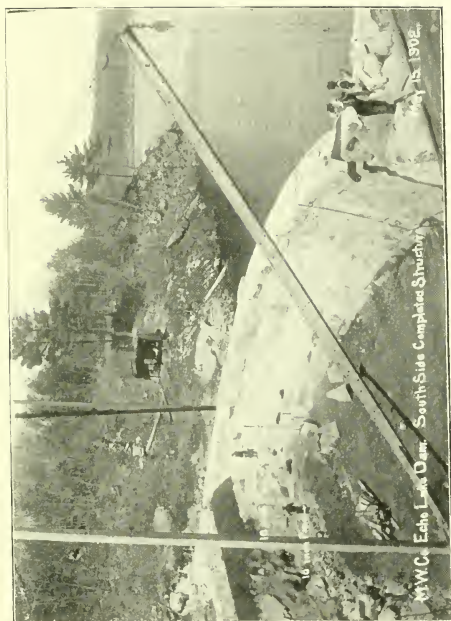


FIG. 2. — COMPLETED DAM — SOUTH SIDE.

PLATE V.

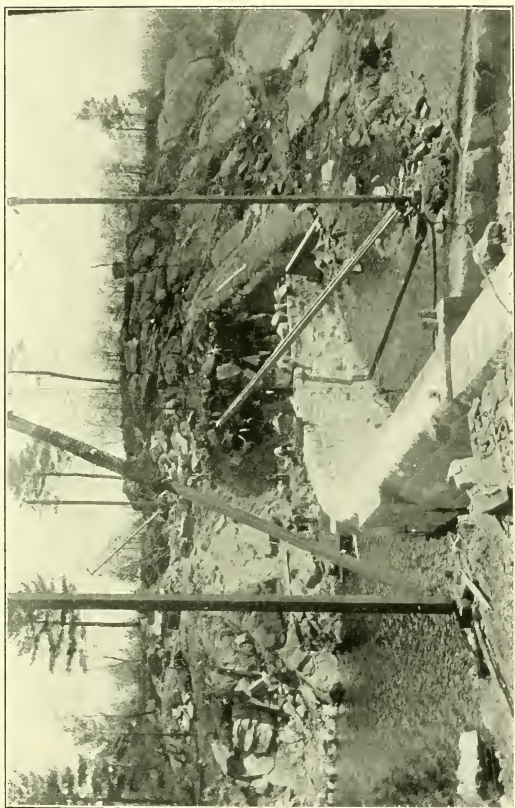


FIG. 3. — COMPLETED DAM — LOOKING EAST.

THE WATER SUPPLY OF NEW ORLEANS AND ITS IMPROVEMENT.

BY ROBERT SPURR WESTON, SANITARY EXPERT, BOSTON, MASS.

[*Read February 11, 1903.*]

When one visits Louisiana, particularly New Orleans, for the first time, his attention is forcibly turned toward the rain water cisterns which are attached to nearly every building. Many of these cisterns are two-storied. This construction permits the supplying of the upper floor during times of drought, as the rain water usually runs first into the upper cistern and then overflows into the lower. The large rainfall is utilized for the domestic supply, because of the poor quality of the ground water and the hardness and muddiness of the river water, the two other available sources. Nine tenths of the city's domestic supply is from the cisterns and the remainder from the Mississippi River, the water of the latter also being used for protection against fires and for flushing gutters. The quality of the rain water varies from very good to very bad, depending upon the location and nature of the collecting surface, the construction of the cistern, the character of the surrounding atmosphere, the season of the year, etc.

Naturally the well-constructed and well-cared for cisterns collecting water from clean roofs in the more open parts of the city, and automatically wasting the first portions of each shower before turning the rain water into the cisterns, may be expected to furnish satisfactory water. On the other hand, the seldom-cleaned, open cisterns, receiving the washings of befouled, dusty, and decaying shingle roofs in the thickly-settled districts, are undoubtedly frequent sources of infection.

Two conditions, however, militate against the use of even the most excellent cistern, namely, the long dry season and the increased use of water due to the increasing amount of sanitary plumbing. Again, the construction of the proposed sewerage

system will invite the construction of more house plumbing, and will consequently demand more water than the sixty inches of rainfall can supply. Already many of the better class of houses use the rain water for cooking, drinking, and laundry purposes only, while the river water is used at the sinks, lavatories, baths, and water-closets. Still other houses are provided with small filters, some of which filter river water to supply the whole house, thereby doing away with the questionable cistern water and its unsightly container.

The necessity for soon obtaining a more abundant and satisfactory water supply for New Orleans has been realized for some time, and a Sewerage and Water Board was constituted by a legislative act of 1899 to build new water supply and sewerage systems. To defray the cost of these works a two-mill tax was levied, which permits a bond issue of about \$12 500 000.

There exists here the unusual example of an American city without sanitary sewers and with only about one tenth of the houses connected with the existing mains of the local water company.

Three sources of water supply were proposed; namely, the rivers to the north of Lake Pontchartrain, the ground water from local deep wells, and the Mississippi River.

The water of the rivers north of the lake is generally uncontaminated by sewage, but would certainly require storage or filtration before use, to perfect its appearance and protect it against chance contamination. This purification and more especially the cost of a long conduit, pumping machinery, etc., exceeding the available fund, prohibited the adoption of this source of supply.

The water of the deep wells, while excellent for use in steam boilers, is alkaline, and has such a high color that purification would be necessary were it used for domestic purposes. This purification would be expensive. Furthermore, the possibility of assuring a supply from this source is doubtful, and was enough in itself to prevent the serious consideration of this source of supply.

There remained only the Mississippi River, abundant, near at hand, and contaminated only at remote points, but, on the other hand, moderately hard, and laden with suspended silt and clay.

Previous attempts to purify the river water made by the New

Orleans Water Works Company in 1892, using mechanical filters with coagulant, but without preliminary subsidence of the raw water, had resulted in a costly failure, and therefore grave doubts were expressed regarding the practicability of any system of water purification, especially upon a municipal scale. However, the Sewerage and Water Board was advised by its experts that if the river water were subjected to proper preliminary treatment it could be filtered afterward without serious difficulty.

Upon the advice of Mr. George G. Earl, M. Am. Soc. C. E., its chief engineer, the board decided to conduct an investigation as to the feasibility of purifying the Mississippi River water, under the general supervision of Mr. George W. Fuller, Assoc. M. Am. Soc. C. E., the consulting sanitary expert of the Board, and Mr. Earl, and under the immediate charge of the speaker.

WATER PURIFICATION INVESTIGATION.

A water purification station was established at Audubon Park, and during the flood season of 1900-01 the behavior of the Mississippi River water was observed under various systems of treatment, and after various periods of subsidence, with and without the aid of a coagulant. A plan and section of this station, reduced from an illustration in the *Engineering Record*, is shown in Fig. 1.

This station contained four complete and adjustable systems of water purification, having a total daily capacity of 93 000 gallons per diem, or enough for 1 500 people. Each system consisted of subsiding basins and filter. The basins could be operated either with or without the aid of a coagulant, and the four filters, two slow and two rapid, were supplied with the effluents from one or another of the basins. Thus was it possible to study, among other things, the effect of plain subsidence for various periods, the effect of supplementary subsidence with a coagulant, the efficiency of the various methods of filtration, the effect of various-sized sands, the effect of various rates of filtration, etc., and to compare the data one with another. The station was equipped with an adequate laboratory, and the work of the station was performed by a staff of four trained and four untrained assistants, besides the speaker. The cost of the investigation was something over \$24 000, an expense which will undoubtedly

effect a saving of several times that amount, besides furnishing valuable initial data for the operation of the plant in practice.

The details of the investigation, including the results of several thousand analyses, are given in a recent report to the chief engineer of the Sewerage and Water Board.

Among other things, the investigation determined the character of the Mississippi River water, the most efficient and economical method of treatment of the water before filtration, and the most efficient and economical method of filtration, and besides, furnished important data for estimating the cost of the proposed systems of purification.

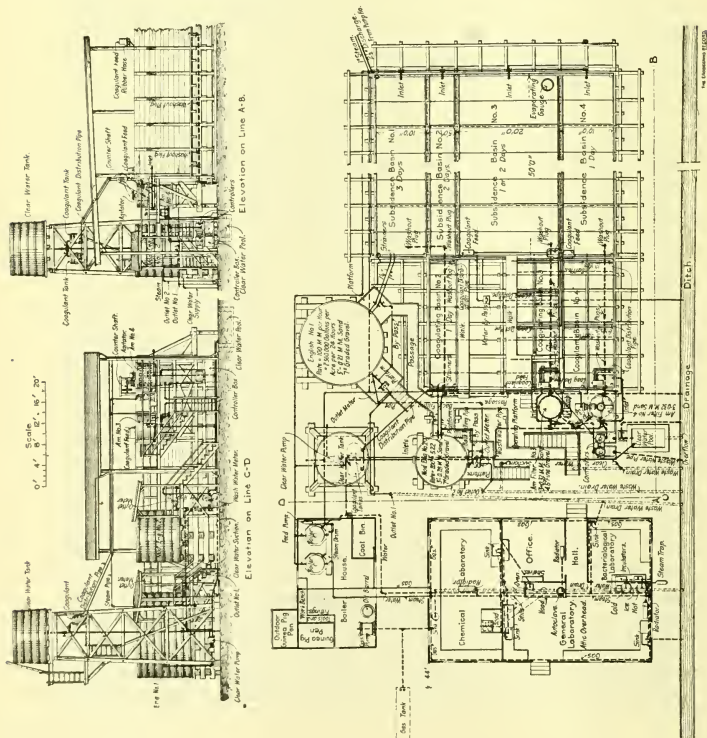


FIG. 1.—PLAN AND SECTION OF EXPERIMENTAL WATER PURIFICATION STATION.

COMPOSITION AND CHARACTER OF THE MISSISSIPPI RIVER WATER.

The Mississippi River is a clay-bearing stream, whose water at New Orleans possesses the following characteristic features:—

1. Wide variation in the amount of suspended matter. This variation is not so marked, however, as in many of its tributaries.

2. The comparatively large proportion of the suspended matter made up of fine clay particles.

3. The absence of sudden changes in the amounts of suspended matter in the water.

4. The frequent but not sudden changes in the character of the water, due to the predominance of one or another of the tributaries.

5. The absence of appreciable evidences of sewage contamination. This is because of the great dilution of the sewage entering the stream, the remoteness of the sources of pollution, and the almost complete purification effected in the river itself by natural agencies during the stream's passage through the delta, the surface of which drains away from, instead of into, the river.

It may be well at this point to give a brief description of the watershed, which, of course, determines the character of the river water at New Orleans.

You will recall that the watershed of the Mississippi has an area of 1 240 000 square miles, distributed among thirty-one states and territories, and its diversity of character may be readily comprehended when one considers that within the Mississippi River basin are the slopes of the Alleghanies and the Rockies; the lakes of Minnesota and the West; the limestone farming country of Kentucky and Tennessee, and the black bottoms of the Dakotas; the arid plains of the Central West and Colorado, and the swamps of the Central Valley.

The Mississippi basin is made up of six tributary basins; namely, the Ohio, upper Mississippi, Missouri, Arkansas, Red and Central Valley.

You are aware of the fact that because of the wide variations in amount of rainfall in different parts of the basin, and because of the varying character of the soil and climate, the discharge of the several tributaries is not uniformly proportional to the area of their several basins. The following table shows the rank of

each basin as regards stream discharges, areas, and rainfalls, as compared with one another:

Basin.	Rank, Based Upon		
	Stream discharge.	Area.	Rainfall.
Ohio	1	2	2
Upper Mississippi	4	4	4
Missouri	3	1	6
Arkansas	5	3	5
Red	6	5	3
Central valley	2	6	1

This table illustrates, among other things, the well-known fact that the discharge of the Missouri River is much less than the discharge of the Ohio, although its area is much greater.

The amount of rainfall varies from 0 to over 60 inches, and averages 29.8 inches per annum, according to the best authorities. This rainfall results in a stream discharge of from 200 000 to 2 000 000 cubic feet per second, or, in other words, from .12 to 1.2 cubic miles volume of water per day.

As has been stated previously, the contamination of the river by sewage is not at all serious in comparison with that of most other American streams. One is so accustomed to hear the Mississippi River called the "main sewer of the continent," "natural carrier of the waste of a teeming civilization," etc., that he is surprised to find that it is a difficult matter to demonstrate by the most delicate tests that the local river has been contaminated. This is evidenced by the fact that *Bacillus coli communis* was discovered only once or twice in five months, although 300 cc. portions of the water were taken for each determination, and that *Bacillus enteriditis sporogenes* (Klein), which is readily isolated from the Red River water at Shreveport, was found at New Orleans on but one occasion.

The urban population of the valley is estimated at 9 000 000 people, including all towns which have a population of 4 000 or more, as determined by the United States census of 1900.

Only four cities, with a combined population of 43 961, discharge their sewage into the river within 600 miles of New Orleans, while the leveed banks prevent the accession of surface drainage.

As you well know, the land of the delta is necessarily highest at the banks of the stream, thus preventing surface drainage into the river. It is evident that the dilution of the contamination is enormous, and that much opportunity is given for the self-purification of the stream by natural agencies while it flows on its way to the Gulf.

The Mississippi River is a very muddy stream, containing on an average about 2.7 tons of suspended matter per 1 000 000 gallons of water. This means that any system of purification must remove enough silt and clay from the future water supply of New Orleans to cover four city squares three feet in depth per annum.

The economical clarification of the water by the removal of the clay and other suspended matter is, therefore, indirectly the chief end of any system of water purification at Orleans, and experience during the investigation confirms the opinion that this removal of clay is accompanied by an adequate removal of bacteria and color, thereby guaranteeing protection against disease bacteria, which might perhaps at some time be present in the unfiltered water.

Many thousand analyses have been made to determine the composition of the river water, with the result shown in the following summary:

SUMMARY OF AMOUNT OF CONSTITUENTS FOUND IN THE RIVER WATER FOR
THE PERIOD BETWEEN DECEMBER 10, 1900, AND AUGUST 17, 1901.

	Parts per million.		
	*Maximum.	Minimum.	Average.
Silica turbidity	1 460	90	405
Total suspended matter	1 040	75	440
Total dissolved residue	250	80	145
Suspended albuminoid ammonia	0.598	0.015	0.188
Nitrogen as total albuminoid ammonia	0.677	0.054	0.251
Nitrogen as free ammonia	0.036	0.000	0.012
Nitrogen as nitrites	0.023	0.000	0.008
Nitrogen as nitrates	0.56	0.02	0.14
Chlorine	20.9	6.0	9.2
Incrusting constituents	24	5	14
Dissolved oxygen	11.5	5.3	9.0
Alkalinity	115	57	79
Free carbon dioxide	75	0	34
Bacteria per cu. centimeter . .	6 500	60	2 065
Temperature, degrees C. (F.) . .	31.1(88)	7.0(44.6)	17.6(63.8)

From data collected during the investigation and obtained from the Mississippi River Commission, it was possible to determine closely the physical character of the river water, as is shown in the following summary:

SUMMARY OF THE PHYSICAL DATA.

- Average suspended matter, 1900-01, 441 parts per million.
- Average silica turbidity, 1900-01, 406 parts per million.
- Average turbidity coefficient, 1900-01, 1.08.
- Average recorded suspended matter, fifteen years, * 688 parts per million.
- Average suspended matter, corrected for analytical errors, 650 parts.
- Average turbidity coefficient for 22 samples of water having between 600 and 700, and averaging 648 parts of suspended matter per million, 1.07.
- Estimated mean silica turbidity, 600 parts.
- Maximum suspended matter, 1900-01, 1 040 parts.
- Mean maximum suspended matter, 15 years, * 2500 parts.
- Estimated mean annual maximum silica turbidity, 1 500 parts.
- Estimated mean annual minimum silica turbidity, 125 parts.

Methods of Purification.—Three general steps in the systems for complete clarification and purification have been considered in various combinations, as follows:—

1. Plain subsidence in basins for several days.
2. Supplementary subsidence in basins with the aid of a coagulant.
3. Filtration, either at a slow rate through sand beds — English filters — or at a rapid rate through filters provided with mechanical devices for cleaning the sand — American system.

1. PLAIN SUBSIDENCE — RELATIVE FINENESS OF THE SUSPENDED MATTER.

The suspended silt and clay in the Mississippi River water at New Orleans contains much very fine material, immeasurably finer than the smallest bacteria. This is probably because of the opportunity afforded for sedimentation of the larger particles during ordinary stages of the river, on the bed of the river itself. These larger particles then become broken into or worn to sizes which can be carried down stream by the lower velocities which obtain in the last few hundred miles of the river.

An idea of how fine these particles are may be obtained by comparing the approximate percentage of suspended matter

* Report of Mississippi River Commission.

removed from the local water for twenty-four hours of plain subsidence with that removed from the muddy waters of other localities for the same period of subsidence, as follows:

Kansas City. Missouri River, estimated percentage removal of suspended matter in twenty-four hours, 82.

Cincinnati. Ohio River, estimated percentage removal of suspended matter in twenty-four hours, 62.

New Orleans. Mississippi River, estimated percentage removal of suspended matter in twenty-four hours, 45.

Plain Subsidence Inadequate to Prepare Water for Filtration at all Times. — On account of the large amount of fine clay particles, the suspended matter as a rule is held in suspension indefinitely, and cannot be removed after any practical periods of plain subsidence, even periods of a week or more.

English Filters and Plain Subsidence. — When this subsided water is filtered at slow rates through thick layers of fine sand a satisfactory clarification and purification results for but a portion of the time. This system would produce muddy effluents for months at a time, and, what is more serious, the cost of cleaning and renewing the clogged sand layer would be prohibitive.

2. SUPPLEMENTARY SUBSIDENCE WITH THE AID OF A COAGULANT.

Necessity of Coagulant. — Since the fine particles of suspended matter cannot be removed by plain subsidence, it is necessary to add something to the water to bring them together in aggregates or groups, which of themselves would have a subsiding value great enough to cause them to settle within a reasonable period. Sulphate of alumina can be used for this purpose, and when added to the water forms an insoluble gelatinous precipitate which, uniting with the clay, causes it to gather into flocks or aggregates, which settle much more rapidly than the diffused clay particles themselves. This precipitate also has the power of attracting, enveloping, or absorbing stray particles of suspended matter, including bacteria, so that the water by this method of coagulation and supplementary subsidence can be made fairly clear.

Difficulty of Removing Last Traces of Turbidity by Coagulant. — In practice, water which has been purified by plain subsidence

followed by supplementary subsidence with a coagulant is, strictly speaking, never perfectly clear. This is because it is difficult to remove the last traces of turbidity by this process alone. Indeed, it is much more satisfactory to make the final step in the clarification and purification process by the use of a suitable filter.

3. METHOD OF FILTRATION.

Two kinds of filters can be used for this final clarification and purification of the effluent of the coagulating basins, namely, the English and American filters. These filters are well known to you all. The English system, you will recall, consists of a bed of sand through which the water, without coagulation, but after being subjected to plain subsidence, filters at a slow rate, while the American system treats the water after both plain subsidence and also supplementary subsidence with the aid of a coagulant, and filters it at a rapid rate through a bed of sand, which is intermittently freed from matter which obstructs the passage of water by reversed currents of water and by agitation. In the English filter the accumulated matter which clogs the filter is removed by draining and scraping.

The main features of the two filters, however, are compared as follows, the English filters being covered and the American filters partially covered:

Area of units: about 1 acre English, 15 x 24 feet American.

Area of 40 000 000-gallon plant: ten acres English, 0.32 acre American.

Net yield or rate of filtration, million gallons per acre per twenty-four hours: 4 English, 125 American.

Depth of sand (inches): 36 English, 30 American.

Depth of gravel (inches): 12 English, 4 American.

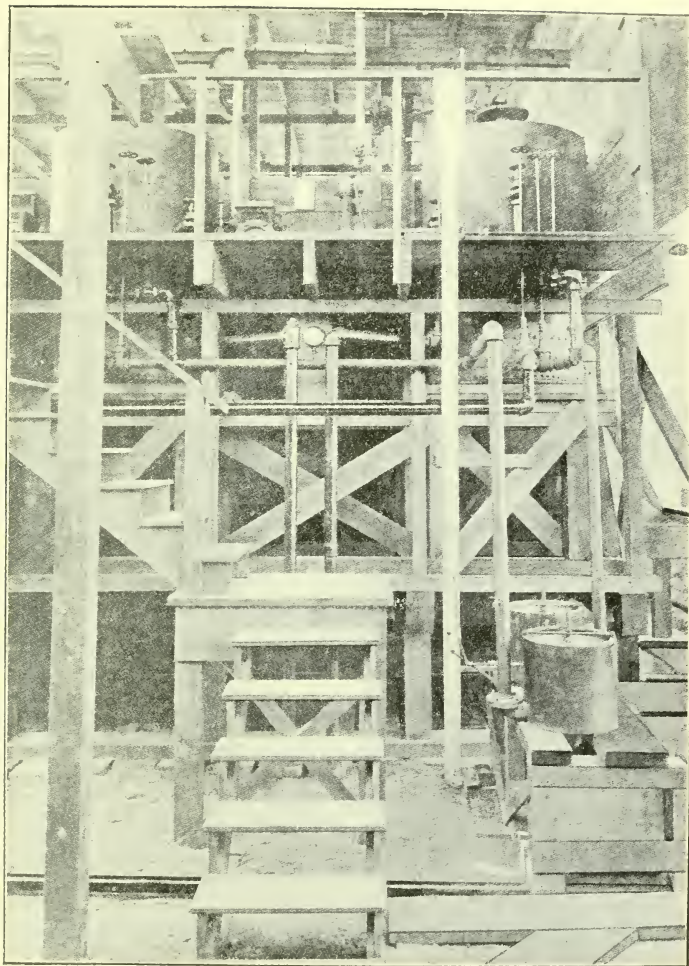
Underdrain system: drain tiles and conduits English, pipe system of double bottom and metal strainers American.

Clogged sand layer cleaned by: draining and scraping English, washing with filtered water until cleaned American.

Vertical height of structure: 14 feet English, 15 feet American.

Relative efficiency for clay removal and relative bacterial efficiency: satisfactory in both.

Both Filters Applicable. — Both filters would be applicable to the purification of the Mississippi River water, provided suitable arrangements for plain subsidence and supplementary subsidence with the aid of a coagulant were provided.



GENERAL VIEW OF AMERICAN FILTERS AND CONTROLLERS.

The sizes and arrangements of the two systems of purification may be compared as follows: —

	Modified Eng- lish System.	American System.
Total daily capacity of plant, gallons .	40 000 000	40 000 000
Capacity of plain subsidence basin in hours flow	12	12
Capacity of coagulating basin in hours flow	24	12
Average amount of coagulant, grains per gallon	3.7	4.5
Coagulant used.	{ Practically continually.	Continu- ally.
Approximate first cost of plant.	\$1 260 000	\$700 000
Total estimated cost of purification per million gallons, including inter- est, depreciation and operating ex- penses, as well as pumping water from river to suction of high lift pumps	\$16.46	\$15.00

It is seen that the American system is less expensive to construct for use in New Orleans than the modified English system by more than \$500 000.

Selection of System Best Adapted to Local Conditions. — Either filter would be adapted to the purification of the Mississippi River water, and the decision as to which would best suit local conditions should be dependent upon the cost per million gallons of filtered water, taking into consideration the difference in first cost.

In total first cost the American system is fully 25 per cent. cheaper than the modified English system, when estimates are made up on the same basis.

Careful Supervision Necessary with Both Systems. — Both systems require careful supervision and attention, as is obvious.

FINAL CONCLUSIONS.

In conclusion, it may be said that the present water supply of New Orleans is neither satisfactory nor abundant, and that sufficient data has been collected during the investigation to allow a system of water purification to be designed which will efficiently and economically purify the Mississippi River at New Orleans.

Furthermore, the available evidence shows that the American system is best adapted to local conditions on account of its low first cost, coupled with adequate efficiency.

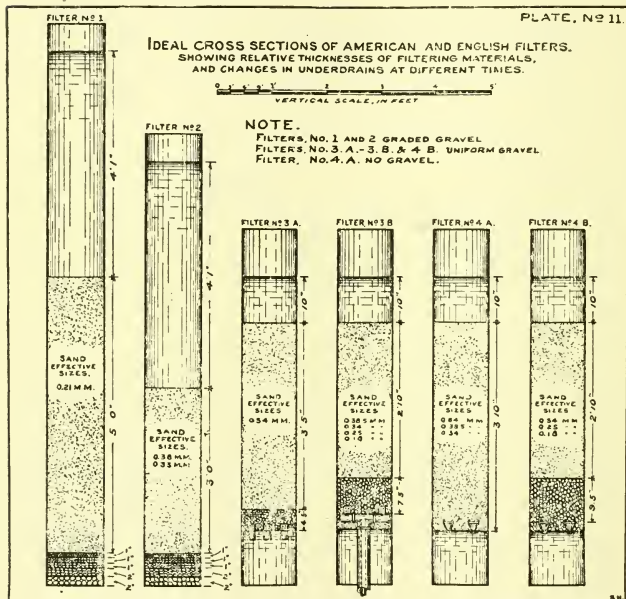


FIG. 2.

During the investigation frequent changes were made in the sand used in the rapid filters, and the bacterial efficiency suffered accordingly. Since the investigation, however, one of the units has been operated for the purpose of supplying water to the wading pool in Audubon Park. Although this plant has been operated during part of each day only, it has shown a bacterial efficiency of 98.2 per cent. This is certainly in excess of the requirements. Furthermore, the appearance and taste of the purified water leave little to be desired.

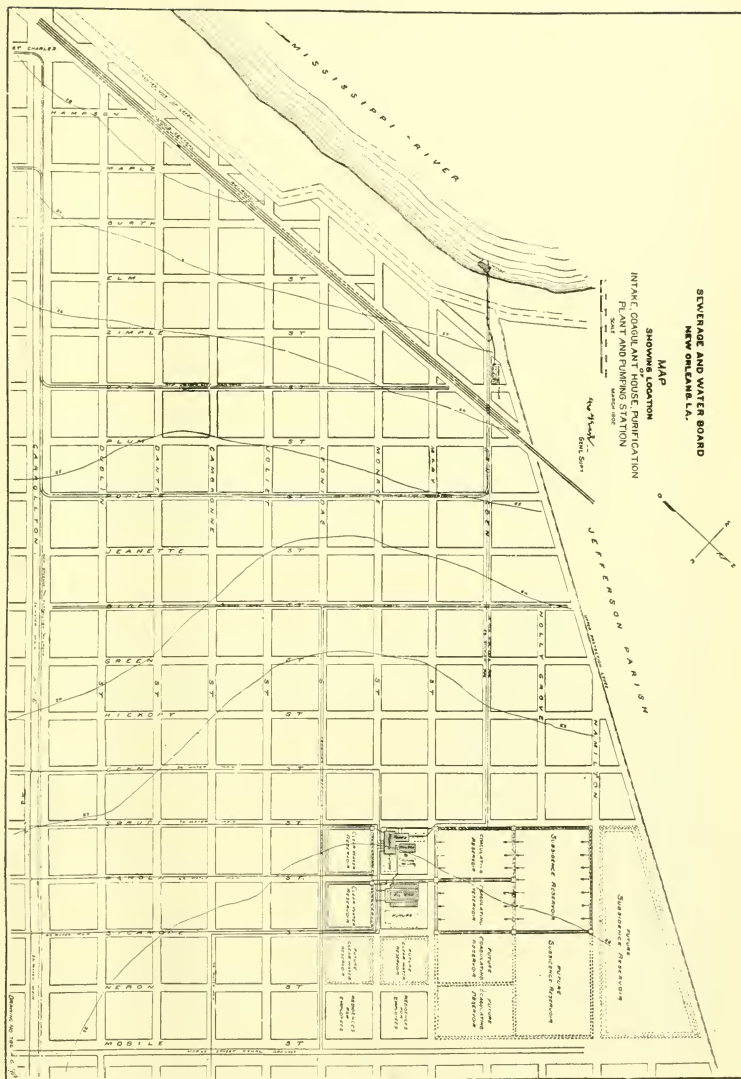
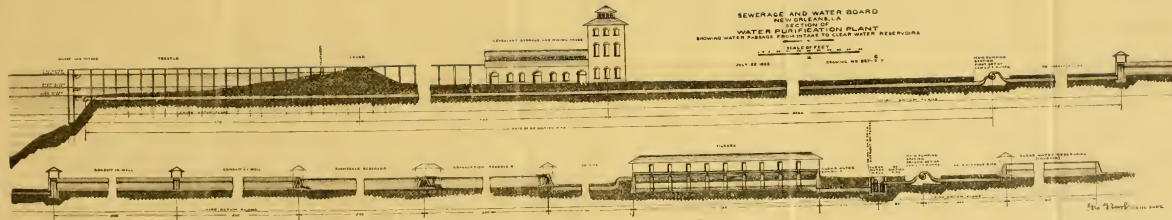


FIG. 3.







ILLUSTRATIONS.

The accompanying illustrations show a general plan and section of the experimental station (Fig. 1); ideal cross-sections of the experimental filters (Fig. 2); general view of American filters and controllers (Plate I); map of proposed intake, purification plant, and pumping station (Fig. 3); general plan of proposed purification plant (Fig. 4); section showing passage of water through purification plant (Plate II); and map of the city of New Orleans, showing the proposed distribution system (Plate III).

DISCUSSION.

MR. L. M. BANCROFT. I would like to ask Mr. Weston what effect the coagulant has upon the hardness of the river water?

MR. WESTON. The coagulant has the effect of changing a certain amount of the carbonate into sulphate; it does not increase the hardness of the water or decrease it. It changes the chemical constitution of the matter which makes up the hardness, and makes the water slightly worse for use in steam boilers, but otherwise I do not think there is any appreciable effect.

THE PRESIDENT. We would like to hear from Mr. C.-E. A. Winslow.

MR. C.-E. A. WINSLOW. I have no doubt many members of the Association read this morning an editorial in the *Herald* on the typhoid epidemic which has just broken out in Ithaca, where, out of a population of 13 000, there are now said to be 340 cases of the disease. I notice that the writer, after speaking of similar experiences in Philadelphia and Chicago, adds: "But yet it seems quite impossible to make the people careful to drink no water which has not been boiled." I think such things ought to make us glad that we live in New England. It is an excellent thing, an admirable thing, that the necessity for boiling polluted water should be put before the public, but it seems discouraging that in some of our great cities the inhabitants must be continually on their guard to protect themselves lest the constituted authorities should neglect to do so.

I think we may pride ourselves on having passed that stage in this part of the country. Of course, eternal vigilance is the price of health, as the New Haven epidemic warned us a year

or two ago; but if you look over the statistics of typhoid fever in Massachusetts you will find that in practically every city and town the typhoid death-rate runs as low as it does in communities where we are certain that the water is absolutely pure—in communities, for instance, where the water is taken from driven wells and where there can be no possible contamination. And I feel that we have a right to draw from this the conclusion that very little typhoid fever in Massachusetts comes from our public water supplies.

Having obeyed the scriptural injunction to cast out the beam from its own eye, the New England Water Works Association is now reforming the country at large. The great work of the National Government under the Hydrographic Survey, in the study of the pollution of rivers, is in charge of Mr. Newell, Mr. Pressey, and Mr. Leighton, all trained in Boston; the new water supply for New York is being studied by Mr. Whipple, that of Philadelphia by Mr. Knowles and Mr. De Berard of this Association; the experiments for the water supply for Harrisburg are in the immediate charge of Mr. Hyde; and we have heard to-day of the great work in New Orleans under Mr. Weston's able charge. I think that all the members of the New England Water Works Association have a right to feel proud of these things.

THE PRESIDENT. We would like to hear from a Massachusetts man who lives up towards the New Hampshire line — Mr. Collins, of Lawrence.

MR. MICHAEL F. COLLINS. Mr. President, I did not expect to be called on to make any remarks to-day, but I will say this with regard to pure water, that in following up the typhoid statistics of the city of Lawrence for the year 1901 I found five cases on one spring-water route, all traceable directly to that one spring. Of course it would n't do to give the name; if I did I would get myself into trouble. When we come to find out how much typhoid fever there is in what they term pure spring water, and then compare it with our filtered water in the city of Lawrence, I feel that our city has reason to be proud of its filter. Last year we figured up our typhoid death-rate, estimating our population at 500 below what the State Board did, and found it to be 1 in 5 700. I think you will agree with me that is a pretty good showing, and

that we get good results from purification, considering we take the polluted water of the Merrimac River. In the year 1902, in a population as estimated by the State Board of Health of 69 000, and as figured by us of 68 500, we had 12 deaths. So I agree with what Mr. Winslow says — Massachusetts has reason to feel proud of its low typhoid fever death-rate, and especially so in Lawrence, considering our supply. At the present time our consumption of water has reached the capacity of our filter, but probably by another year we will have an addition to it, so we will feel a little easier than at the present time. If our President had informed me he was going to call on me I would have had some figures to present, but I am unprepared to say anything further at the present time.

A LITTLE TALK ABOUT WATER RATES .

BY JOHN C. CHASE, C.E., DERRY, N. H.

[*Read March 11, 1903.*]

Yielding in a thoughtless moment to the solicitation of our efficient Secretary, I consented to be responsible for a paper to be presented at one of the winter meetings of the Association. His sugar-coated privilege of selecting any subject of the many on which it was assumed I could speak with authority seemed to render the task an easy one, but the sober second thought "in the cold, gray dawn of the morning after" caused grave doubts of my being able to present anything of interest or value upon any topic. The late experience of that body of investigators known as the Committee on Private Fire Service — to curtail their title somewhat — suggested that something about water rates might be a novelty, hence the subject announced on the program of the day.

Next to a congestion in the supply caused by frozen hydrants or a limited rainfall there is, perhaps, no feature of water-works management that gives the average superintendent more concern than the one of water rates.

That they are a proper and legitimate charge goes without saying, whatever our socialistic friends may hold. That they should be equitably assessed on those benefited needs no argument. How the charge should be adjusted is apparently a question not easily answered, and one upon which widely divergent views are held, if the methods in vogue are any criterion.

Probably a great degree of the irregularity in the manner of assessing water rates is due to the fact that in the infancy of the business there was no simple, cheap, and efficient way of measuring with approximate accuracy the quantity of water used by the individual consumer. At the outset we are confronted with a condition appertaining, perhaps, to no other line of business, and conditions, like theqries, are not easily gainsaid.

A goodly number in the average community are benefited only in an indirect manner by a public water supply. They may have undeveloped property on the lines of mains where no use of water is made, or they may be outside of the limits of the pipe system and get only an indirect benefit from the existence of a water-works system in the municipality to which they belong.

Now how can the burden be adjusted so as to be equitably borne by those benefited? The establishing of a proper schedule predicates the determination of the amount of revenue required. This should be sufficient to pay the expense of operation and management, interest charges on the capital invested, and create a sinking fund to cover depreciation of the plant and maturing interest-bearing obligations.

The amount necessary to be raised having been ascertained, it is next in order to settle what proportion shall be paid by the municipality as a whole, through the agency of the general tax levy. This compensates for hydrant service, and secures a contribution from those who are non-users of water but nevertheless benefited to a greater or less extent by the existence of the system.

What this proportion should be will vary in different communities and at different times in their history, and no hard-and-fast rule for determining it can be given. Inasmuch as the cost of a system to furnish efficient fire protection is largely in excess of the cost of one that would be of ample capacity for domestic supply alone, it would appear that a liberal portion of the amount of income required should be obtained by means of the general tax levy. The cost of additions to the plant should be treated as an increase of capital invested and not loaded on to the income account. Probably there is no better way of adjusting the proportion to be paid under this head than by a hydrant rental, which gives a tangible unit of measurement.

For all use of water in public buildings, for street sprinkling, sewer flushing and public fountains, useful or ornamental, the municipality should pay the same rates as any private consumer for like service, the water department being conducted strictly as a business enterprise.

Thus much for the municipality; now for the individual consumers. How shall they be assessed? Again a condition and not a

theory confronts us. In one city the family is made the basis of the rate, in another the fixtures, and with these two extremes there are complications and compromises galore. Of late years the water meter has been in evidence to quite an extent, although it is looked upon with disfavor by the consumer who desires to pay a fixed rate and have the unrestricted privilege of using all that he desires, which practically means that he is willing to pay only a minimum sum for a maximum quantity. It may be safely assumed that the consumer who objects to being supplied by meter either knows that he is using an excessive amount or has his suspicions that such is the case. Until that millennial time when the lion-hearted seller of water and the lamblike water taker are led captive by the innocent water meter, schedule rates will be in use as heretofore.

Looking upon them as a necessary evil for the time being, an effort should be made to have them sufficiently in detail to be reasonably equitable and yet not so complicated as to be unduly troublesome to adjust in actual use. From an equitable point of view it would appear to be necessary to take into account the number of rooms, fixtures and persons on the premises supplied. In some cities a still finer distinction is made, and the subdivision of "mealers" and "roomers" appears. The application of the personal numerical factor is complicated in Southern cities by the fact that the servants do not usually reside on the premises, and the claim is also frequently made that the rate should take cognizance of the fact that the family washing is not done "on the lot," to use the provincial term. The non-use for drinking purposes of the water supplied has also been the basis of a claim for rebate in the speaker's experience, and possibly may not be an uncommon experience in sections of the country where water cuts no figure as a beverage.

Until the respected head of Harvard University and his followers have met with a pronounced degree of success in their campaign for larger families, it may be as well to pay no attention to this factor in establishing the domestic water rate, for at the present time the average American family rarely exceeds the limit usually established by water departments. The number of rooms in the house may also be ignored. While it is true that more water would naturally be used in taking care of a large

house than a small one, yet the inequality is corrected to a great extent by the proportionate amount of the general water tax paid by the larger establishment. That a charge should be made for duplicate fixtures appears to be beyond dispute, for it is certain that they facilitate the use of an increased quantity of water, to say nothing about the chance of leakage, which is responsible for the loss of a large proportion of the water supplied in the average city.

The simplest schedule rates that I have seen are given as a matter of personal experience. A basis charge was made for the initial fixture of each class for a family of five persons. Additional fixtures were charged from one to two dollars per year according to the class. For each person in the family in excess of five, ten per cent. was added, which made the rate elastic enough to cover the case of boarding houses. For all other consumers meters were required, with a minimum charge of ten dollars or more per year, according to the size of the meter used, and any schedule water taker could have a meter if that method of payment was preferred. The water company supplied the meters and kept them in repair, the consumer paying the initial cost of setting and boxing. At the present time about two thirds of the services are metered, being practically all whose annual rate would exceed the minimum meter rate.

The custom in some places of not permitting the use of meters on residence services is condemned as an arbitrary exercise of an assumed right to oblige one person to help make good the loss occasioned by the willful or negligent acts of another.

There is another class of customers whose rates and privileges have received an inordinate amount of attention in the past few months. It is hardly necessary to say that reference is made to the "fire service" rates. Notwithstanding the more than ample consideration of this subject, it is still unsettled and can hardly be ignored at the present time, although any allusion to the matter may prove to be an apple of discord. As premised at the outset, the supplying of water for fire purposes is made a function of the municipality, and the proper proportion of the water department expense met by general taxation. The regular fire department stands ready to flood the premises of the individual consumer should occasion arise and the supply be sufficient, and the

actual loss from the water used often exceeds that caused by fire, because of the necessarily inefficient and often tardy way in which it is used. Now if the consumer chooses at his own and not inconsiderable expense to equip his establishment with the means of more quickly and efficiently using the self-same fluid that belongs to him by right, why should he be obliged to pay for the privilege, especially as he is more than likely to reduce the actual consumption of water to a large extent? The only answer, to my mind, that carries any weight is that he cannot be trusted to make no illegitimate use of the opportunity to divert the water for other purposes. Granted; but I am inclined to consider it an insult to our American intelligence if some means cannot be devised by which those who are disposed to "tote fair" may be relieved from the system of double taxation to which they are now subject in many cases. As a matter of course, the consumer would be required to pay any extra expense incurred by the water department in giving him the desired facilities and the installation and inspection of any apparatus designed to prevent or detect the unlawful use of water. Inasmuch as the actual use of water for the extinguishing of fires in a manufacturing establishment would be but a small proportion of the total amount used in a term of years, it would work no hardship if the whole supply were taken through a meter, thus entirely eliminating the inspection feature. Of course, this idea will not meet with the approval of the insurance companies, but "that is another story," and having enough "troubles of my own," I pass their grievance by.

But I imagine some representative of a water company saying, "That course of reasoning is all very well where the water works are owned by the municipality, but we are in the business for profit, not pleasure or health." The fundamental principle is the same. When a water company contracts with a municipality to furnish water for fire purposes it stands in exactly the same relation to the consumer as a municipal water department.

As before stated, the water department should be conducted as a business enterprise. Churches and eleemosynary institutions should pay the proper charge the same as any other consumer. Those who buy water by the thousand gallons and sell it by the quart, like the rectifier, brewer and the dispenser of "soft drinks," or the manufacturer who reduces his insurance by the introduc-

tion of a sprinkler system, are all on the same plane with the ordinary consumer. It is water alone as a raw material with which we have to deal, and while it may be considered a privilege to have it at our disposal, the only measure of its value, under existing conditions, is the quantity actually or presumably used.

FUEL: WHAT WE DON'T KNOW ABOUT IT.

BY EDWARD ATKINSON, LL.D., PH.D., PRESIDENT BOSTON MANUFACTURERS MUTUAL FIRE INSURANCE COMPANY.

[*Read March 11, 1903.*]

Gentlemen, — I claim no exact knowledge of any of the physical sciences. My attention has been called to what may be called the principles of combustion only since it became my profession to make the prevention of loss by fire an applied science. What I may say to you will therefore be the result of observation coupled with such smattering of science as one must pick up who is obliged to select scientific experts in all branches of physical sciences, and who must make an effort to understand their work in order that he may make it plain to the managers of the factories.

Perhaps the greatest waste of a wasteful people is the waste of fuel. Certainly the most wasteful example of modern mechanism is the steam plant, consisting of boiler and engine. The best results claimed in this country for the most perfect boiler and engine plant is the conversion of less than twelve per cent. of the potential of the coal into work. A little more is claimed in Great Britain, but I have seen no evidence to convince me of the fact. The locomotive and marine engines are far more wasteful, and yet in the marine engine a cube of the compressed and dried mud which we mis-call bituminous coal, which will pass through a ring of the size of a quarter of a dollar, will drive one ton of cargo and its proportion of the steamer one mile upon its way by the conversion of only five or six per cent. of the potential of that little cube into the work.

It is computed that out of 250 000 000 tons of bituminous coal mined last year 85 000 000 were consumed in locomotive boilers on railways, in which not over five to six per cent. of the potential is converted into work, or about 5 000 000 tons.

Compare this waste with the turbine wheel, which Boyden

carried to such perfection as to utilize more than ninety per cent., I believe ninety-five per cent., of the potential of the water in a wheel of so fine a character that in order to keep it up to its work the guides needed to be often scoured with a crash towel to remove the slime left by the water.

The electric dynamo is another example approaching perfection. More than ninety per cent., I think, more than ninety-five per cent., of the power applied is converted into work.

The generation of power from coal is worked by combustion, converting the gases of the coal into what we call heat. Heat is a form of physical energy, said to come directly from the sun. I venture to suggest that this is an error. If the vibrations emanating from the sun brought the energy of heat directly to the earth, then the tops of the mountains, especially in the tropics, where the highest mountains are, would be the hottest places in the world and the deep valleys would be the coolest or coldest. The reverse happens to be true. How, then, is heat generated from the sun upon the earth? It is of course known that the whole body of the sun is in a state of intense incandescence. The photosphere is disclosed by the spectroscope, consisting of all the known substances, metal, mineral, and the like, in a gaseous condition. From this body emanate immense vibrations passing out into the ether of which we know little or nothing. As these vibrations, undoubtedly of intense heat, pass beyond the direct influence of the incandescence of the sun, must they not become intensely cold until they approach the earth? Otherwise why would the outer atmosphere be cold and the tops of the highest mountains, even in the tropics, be covered with perpetual snow? It is only when these vibrations come down into the lower atmosphere or strike the earth itself that heat is generated. How? Is not the heat generated by friction, the friction of these vibrations or undulations forcing their way through the more dense atmosphere after having passed through the ether? Where these vibrations or undulations strike vertically, as in the tropics, heat may be generated not only by the friction of the atmosphere but by the concussion with the more solid earth, while in the temperate and frigid zones these vibrations striking at a more and more obtuse angle make less concussion or glance away into space without promoting the excessive friction and heat of the tropics. I

do not know whether this theory will stand among scientific men. It may be in the books, and if so, I wish I had the citation. So far as it goes, it is a hypothesis of my own; not consciously derived from reading. From that heat generated by the sun we of course derive the possibilities of life, the growth of plants, the formation of mud ultimately converted into coal. The sun is the primary source of heat; friction and concussion the secondary sources.

What, then, is coal? Again I must deal with my slight knowledge of geology. We live here upon the spurs of the great Laurentian chain, called in the United States the Appalachian chain, the oldest rib of the continent. It consists of the igneous or crystalline rocks, which have been converted by heat into granite, gneiss, and the like. They are without fossils or organic remains, but contain potash and other elements of fertility in very large measure; the granite is pervaded with fossil water in hygroscopic form, which renders it so bad a resistant against fire. The small particles of hygroscopic water, being converted into steam, rend the granite into sand; so that in the basement of one of our factories where there were alternate oak and granite posts exposed to a very hot fire, the oak having been put in to supplement the granite, the latter were completely destroyed, while the oak were carbonized only to the depth of an inch, holding up the building and saving a large loss.

We know little of the contour of this primal continent. We do know that it was flanked on the west by the extension of the Gulf of Mexico as far north as the blue grass section of Kentucky, and that the outlet of the St. Lawrence was once in that direction. We know that the ocean of that period was of very different chemical quality than the present ocean — far more corrosive. The authorities of the Boston Gas Company once consulted my old friend, Prof. T. Sterry Hunt, on the expediency of making an artesian well at the North End in order to avoid the heavy water tax which they paid on their steam plant. He told them that in this formation they might strike water, but it would be fossil water of a certain chemical quality, which would be utterly useless for a steam plant because of its corrosive quality. They were not discouraged. They put down the well; they struck the water, and it corresponded in its corrosive action to the theory of Professor Hunt. This water ate away the granite and the gneiss

until gradually a soil was formed. Then followed the period of the coal measures, when plant growth of the most profuse kind passed year by year into partial decay, protected from total conversion into gas by being buried under water. This plant growth consisted of the carbon and the hydrocarbons derived from the atmosphere, and the albuminous or nitrogenous elements derived from the soil. Year by year, as one plant succeeded the other and the other was buried in the mud, the anaërobe microbes which thrive in water, but are killed by exposure to the air, fed upon the albuminoids, converting them back in the process of decay into gases and restoring them to the atmosphere, while the carbon remained, hence the will-of-the-wisp, marsh gas, etc. All this change to coal must have taken place under water in the form of mud, because when vegetable matter falls upon the surface of the ground after one set of insects and microbes, known as aërobes, which pervade the air, have disposed of the albuminous and nitrogenous parts of the plant, another set of microbes attack the rest of the decaying mass, carbon as well as other portions, and convert the whole back into the gases from which the carbon was originally derived.

The deposits of coal are not confined to the carboniferous series or era. The great deposits of that period, consisting of the anthracite, the semi-bituminous and large deposits of the bituminous coal, were subjected to the great disturbance of the shrinkage of the earth's crust. The anthracite coals were subjected to an enormous pressure, which rendered volatile the hydrocarbons and left the fixed carbon, from ninety-two per cent., sometimes ninety-eight per cent. of the whole volume. The semi-bituminous coals, and the best bituminous coals, those known as coking coals, were subjected to a less measure of pressure and to a less degree of heat; they retained the hydrocarbons which are mis-called bitumen, yielding the qualities which are so well known. But as we pass west into the more recent geologic periods, we still find the process of conversion of plant life into mud and then into coal, yielding the almost level deposits of the coal of the middle West, which has been subjected to a light pressure, is friable, dirty and smoky, covered in many places by the loess, or wind formation. But not yet the end. When we reach the far West, the youngest and vol-

canic section of the country, here again we find that plants have grown and decayed and have formed what is known as lignite or brown coal, which in the volcanic uplift has been brought to or near the surface, the water draining away, leaving it a friable, carbonaceous material, containing twenty-five to thirty per cent. of water in the hygroscopic form, and when compressed into briquettes making a good fuel. Lignite is nothing but fossil mud.

Again, all over the Southern states, Alabama, Mississippi, Louisiana, and Texas, where for geologic ages must have been great mud lagoons while the water was receding, there are immense lignite formations from which there may be hereafter derived a clean, smokeless household fuel, possibly or probably without the necessity of adding any tarry or bonding material to the lignite. That is a question of mechanics. But we have not come to the end of the coal and lignite measures yet. We may now come back to the modern period, the alluvial, and again we find plants growing, decaying, forming great, deep bodies of mud protected by water from the destructive organisms of the air while the anaërobes are consuming the nitrogenous portions, converting them into gas which bubbles up in the bogs, marsh gas and the like, passing on for conversion and reconversion throughout the ages. All things have been gas — all things will be gas. That process is going on in Massachusetts over great areas; and here is probably the first specimen of mud — clean slimy mud, much more free of fibers than peat — which has ever been converted into fuel from the mud of the sluggish Taunton River, or from any other mud in the United States, although the peasants of Ireland have been making and burning mud briquettes for generations.

This parcel represents mud fuel dried by Professor Norton by artificial heat and very slightly compressed. It has a potential higher than that of hardwood or the best of peat fuel. A parcel of fifteen pounds placed in an open grate on a brick floor outside of any fireplace, and lighted with some paper, yielded a clear, blue flame about a foot and a half high, with very little smoke, a very strong heat, and burned out in about an hour and a half leaving a considerable volume of very fine ash, of which the proportion is larger than we expected. This ash probably consists of dust that has blown in upon the surface of the bog, or possibly of the siliceous coverings of the grass which do not decay.

The way in which I happened to turn my attention in this direction may interest you. We were at my summer place at Mattapoisett, on Buzzard's Bay, when the coal strike took place, and although I had fortunately laid in a full supply of coal in Brookline, I began to look around for emergency fuel. I went out into the woodland on my place, consisting of hardwood, where dead leaves and a very vigorous growth of ferns had been decaying upon the top of a glacial drift; dug up some sod, finding from one to three feet of black humus or decayed vegetable matter underneath; took the sod into the kitchen and placed it in an iron pan to dry off. My Irish cook said, "Are you going to burn it, sir?" I said, "I am going to try to." "Oh," she said, "that would make a fine back-fire if it had been out in the sun and air to dry awhile." I said, "What do you burn in front, peat?" "No, sir, not in my part of the country. We burn turf. Turf is the black mud, sir, that comes under the sod. It is dug out and worked in a trough like a bed of mortar; then made into blocks, spread out in the sun and air for a few weeks, and when it cracks it is ready to burn. It makes a very hot fire."

This account has been confirmed by two other very intelligent Irish women, one of whom, hearing me talk about it in the electric car, asked leave to say a word, saying that she was so glad to hear some one talking about turf. "There's millions in it, sir, if you go at it in the right way. There's turf around my place in Newton to heat the whole county, and nobody seems to know anything about it." She also made the distinction between turf and peat, and this accounts for the stories that have long been told of the bursting of peat bogs in Ireland, overwhelming farms and valleys. The peat bog, as we know it, is in a hollow. The specific peat plant, as we know it, is the sphagnum moss. None of these bogs could burst and overwhelm a neighborhood, because they are always the lowest point in that neighborhood. In point of fact, in the very humid climate of Ireland, what has sometimes been referred to as "grass peat" forms with great rapidity upon the slopes of the hills, yielding both the sod and the turf to which reference has been made, and when after very heavy rain this black mud becomes saturated, the sod bursts and the mud pours down the slope of the hill.

In Germany, where the greatest progress has been made in the

conversion of peat into briquettes, the common name is "*Torf*." A very large part of the smokeless fuel of Germany is derived from peat or *torf*, or from lignite or fossil mud, both being converted into briquettes, usually with a slight admixture of mineral tar or pitch to bond them. Consul-General Mason's reports give minute accounts with diagrams and descriptions of the machinery used. I observe, however, that the mechanism described is almost identical with mechanism which I invented in 1867 for converting peat into briquettes at the Indian Orchard Mills. The price of coal in that paper money era being very high, we successfully worked a peat bog for many months in a boiler plant of mills of about thirty thousand spindles, giving it up when coal went back to normal prices. But what we call peat, which is very full of hollow fiber and of the fibers of the grasses that grow on the top of the moss preserved in the peat, is very much more difficult to compress, and takes much longer to dry than this slimy, nearly homogeneous black mud from the Taunton River. Professor Norton is now having a small machine made on my original plan for the conversion of the mud into briquettes, and we shall, ere long, be able to turn out a sufficient quantity for a more complete test, with some approximation toward the cost of the work.

But there is another aspect to this case, namely, the conversion of meadow mud into gaseous fuel. That is now the direction of all invention. The gas engine will, in my judgment, wholly displace the stationary steam engine within a short period of time.

Recent inventions in the conversion of the slaty culm of coal into gas, called the Mond gas process, may tend to a solution of this question. It has been necessary in Great Britain to utilize what had been waste products of the mines more fully than we have. In fact, the low price of our coal has retarded invention in this country. By the Mond process, now taken over and being introduced in this country by R. D. Wood & Co., of Philadelphia, culm, no matter how slaty or dirty, if it contains a certain quantity of coal, can be converted into gas. The crude material is subjected to a lower temperature than by former methods, so that the gas is dissociated, as I understand the case, without melting the refuse slate or other material, and converting it into slag or clinker. Possibly this process may be applied to meadow mud even without complete drying. It occurs to me

that the mud may be reduced in its water content until what remains becomes in a measure hygroscopic, and not exceeding the proportion of water required in the manufacture of water gas from anthracite and water. If this proves to be feasible the finely divided or hygroscopic water combined in the carbon of the mud may be more readily dissociated and mixed with the gases of the carbon than it could be by any other process.

All this is hypothetical. The only claim which I make is to having called attention to what seems to me a great fact, namely, that the mud in the fresh and salt water meadows as well as the peat in the peat bogs may now be regarded as a vast source of energy, requiring for its conversion into heat mechanical appliances rather than any other, so as to bring the material into a semi-solid shape or into gaseous form, in which it may be converted into heat and power. If all this proves to be delusive, I have no scientific reputation at stake, and may have lost nothing in repute for having started in a purely empirical way to develop the subject. On the other hand, if the difficulties can be surmounted at a cost that will relieve the increasing scarcity of anthracite coal, only to the supply of household fuel; or if it shall prove feasible to convert this vast store of energy, or, as we may call it, coal in its primary process, directly into heat without the lapse of geologic ages, then I may have added a benefit to society which will be worth remembering. I may then receive a compliment similar to one which I received on the Aladdin Oven, "So simple that nobody but a fool would have thought of it"; or like one given me on his first vision of the diffusion of light by ribbed glass, by a distinguished oculist, who exclaimed, "Why did not some donkey ever think of that before Atkinson?"

* After I had made this record and thought that I had come to the end of it, information began to fall in from every point. A German in Portland, Ore., referred me to Brockhaus "*Conversations-Lexicon*," the latest edition. As I do not read German, my son looked up the matter, and I am again impressed with the fact that our abundance of coal has kept us very far behind in the way of useful inventions developed from peat, not only in the matter of fuel, but its application to many other purposes.

There are three varieties of peat, of "torf," as it is called in

* The following matter has been added by Mr. Atkinson since the paper was read.

Germany, each varying greatly from the other, and all applied to useful purposes : —

The "heath moss turf" moor or highland peat, growing on high uplands, consists of the partially decayed remains of the heather, of broom, of cotton grass, so-called, and varieties of sphagnum moss which require no water.

Then comes what is sometimes called grass peat, like that made from the banks of Ireland; the black or dark brown peat, mainly decayed grasses and the weeds that grow among the grasses.

And, lastly, the peat of the regular peat bogs corresponding to our own, consisting chiefly of the sphagnum moss and of the water plants.

The surface heath moss turf has very little value for heating purposes. It has great absorbent power. When saturated with rosin it is converted into kindling. It is made in various compounds into paper, carpets, "mossturfstone" for partition walls, packing material, especially for meat and drink, beer glass stands, carpet linings, fireboards, sound dampers, steam pipe coverings, boards for insect collections, stuff for bandages, and filling for mattresses and bed cushions for the sick. The peat cotton grass yields fiber that is spun into garments and horse-blankets. The black turf below is made into fuel.

The grass peat or turf made from these deposits is burned not only in Ireland, but all over Holland, Denmark, and many parts of Germany and other European countries, where it is practically the only fuel. In Germany the yearly consumption is rated by the million tons. In agriculture the moss turf layer of the highland moor and the sod of the grass turf layer occupies a very important place. For certain purposes it is thoroughly dried and ground into peat meal, which will soak twenty-five times its weight of moisture. It is then used to take the drainings of the stalls, to mix with the straw refuse of the stables, and, when mixed with a little "Kainit," one of the products of the Stassfurt potash mines, it retains the volatile elements of manure. Its further advantages are that it assures a pure stall air and healthy bed. It prevents animals from eating the rotten straw, it also absorbs grease and gases. It is a great deodorizer in ditches or barrel contents. By the addition of two per cent. of sulphuric acid it becomes destructive to the cholera and typhus bacilli with-

in twenty-four hours. In several German cities peat meal at the rate of about two hundred grams per day for each inhabitant is mixed with the collected sewage. In Hamburg I observed that disinfectants were scattered on the streets before the watering carts. It is used in composting the waste of the sugar factories and the refuse of slaughter houses, and, as I have previously said, for packing eggs, meat, fruit, and the like. It is said that sea fish packed in peat meal have been found still good after eighteen days.

Shortly after my mind had been turned toward the discovery of an emergency fuel, and I had made my first experiments on turf, I happened to make a tour of observation in the West among the great agricultural tool works and others which we insure. On my way I observed the enormous waste of corn stalks, on which Professor Norton had already measured the heat units for me with a view to compressing the corn stalks for fuel. With each crop, approximating seventy million tons of shelled corn, there are at least one hundred million tons of stalks, leaves, and cobs, of which not over one half is yet shredded or saved in any other way for fodder; the rest encumbers the field. It occurred to me that there would be no difficulty in compressing this material immediately after shelling the corn, which is now done by machinery without removing the ear from the stalk. At that period the saccharine is not fully dry and might therefore serve as a bond, but on further reflection it seems that sorghum, which is more reedy, and contains a larger measure of saccharine, could be grown for fuel at very light cost. On good land it will produce ten to fifteen tons dry weight per acre at a cost of only one dollar to one dollar and a half per acre for the planting. If then a cheap and effective press for farmers' use could be made, every farmer could grow his own fuel on one or two acres of land out of a farm of one hundred and sixty acres; and, if the ashes were saved and spread upon the field for the next growth of leguminous or nitrogen-gathering plants, the farm could be improved by the process.*

* Since this was sent to the press a Western machinist of large capital has presented plans of a very simple press for making a cylindrical bale of cotton by rolling laps, differing from the presses now in existence, and capable of being made on a small scale for farmers' use in rolling sorghum stalks into logs, say four feet long by eight inches diameter. On calling the attention of the inventor and promoter to this great field, he became much interested, and said he would take the subject up and work it out to test its feasibility as soon as the present crop of sorghum should be in condition.

This project appeared to be a very simple one to several of our Western clients, who will take it up. One, the head of a large agricultural toolshop in Rockford, Ill., goes further. A box is on the way containing the roots of the corn plant, which are now an absolute waste and encumbrance, his computation being that the roots from five acres of corn might serve for a year's stock of fuel for the average farmer and that these could be piled away after harvesting, to be worked up during the winter months by cutting and compression.

Whether these visionary suggestions of growing fuel in the West and working mud in the East may become burning facts is, therefore, a merely mechanical problem. At the present time my scientific friends are more sanguine of success than I am.

Since compiling this information from public documents, others have been sent to me by Consul-General Mason, of Berlin, — one describing a very recent invention of the Zeigler apparatus for converting certain varieties of peat, especially that from the peat moor, into coke and many secondary products. The extent of these peat moors in Friesland, Sweden, Germany, and other parts of Europe is something of which we have probably little idea. In Friesland colonies have been planted on the peat moors as far back as the fourteenth century, to clear arable land from the encumbrance of this peat, while in Germany the work has also been undertaken for the recovery of the land, which has now apparently become of secondary importance to the conversion of the peat.

The Zeigler process was invented in 1895 by one of the eminent German chemical engineers. It has been thoroughly investigated on behalf of the Russian, Swedish, and German governments; has been approved, and is now coming into work in various places.

The peat moor yields machine peat, that is, briquettes, from which are derived: —

Coke, for use in metallurgy, equal to charcoal.

Heating coke, which gives flame, and from which all the hydrocarbons have not been driven off.

Crude tar, from which are derived: impregnating tar, paraffin and gasolene, tar water, yielding ammonium sulphate, methyl alcohol, and other products.

Volatile products: power gas, lighting gas, and heating gas.

Secondary products: peat straw, peat meal, and peat wool — leaving the land in excellent condition for cultivation. The peat meal mixed with the molasses of the beet sugar factories makes a valuable food for cattle. It is also used as a non-heat covering for ice and as a covering for compost heaps to save the escaping ammonia.

In the coking process gases are thrown off from the volatile hydrocarbons, which are then used for heating the ovens, and may be used in gas motors.

The upper layer of the moss peat is converted into the straw and meal to which I have previously referred. It is said that from the production of 22 000 tons of peat briquettes, 600 tons of the wool fiber are yielded.

Elaborate figures are given of the cost, but as these are based on German wages and the work is largely handwork, they may be of little service to us until we may substitute mechanical processes for the handwork of Europe, thereby developing high wages and low cost.

The geographers will know whether we have any of these high peat mosses in this part of the country. We have something which must closely correspond to them in Alaska. I have long attempted to keep the track of the developments of new gold fields, anticipating a considerable depreciation in gold, which I think is already manifest. The latest discovery has been at Cape Nome. From the gold-bearing beaches rises a crest, then a depression, and back of that depression for a distance of more than one hundred miles in length, and twenty or thirty miles wide, is what is known as "the tundra," corresponding to the tundra of northern Europe, — a level plain, covered with two to three feet of the moss and other plants. Under this for many feet in depth are sands corresponding to the sands of the beach, and in sections of great area, justified by the geological reports, are great beds of gold-bearing sand, in which the fine gold is held throughout the mass. A large section of this has been taken up by a company of which a large capitalist of high repute, well known to many of you, is the chief promoter. He has been on the ground all winter with large amounts of machinery, ready to set up this spring and to begin taking out and washing this sand by scien-

tific methods. The scarcity of fuel is one of the main difficulties at this point, and if the tundra can be converted into fuel by the process described, another step will have been taken in cheapening gold, or, in other words, in raising general prices.

I have thus laid before you the most visionary scheme that could enter the mind of a practical man. In all these investigations of peat and turf it never seems to have occurred to any one that the deep black mud of our fresh-water swamps, by our sluggish rivers, or of our great areas of salt marsh, must be substantially of the same composition, and may yield similar products. I was forced to make a premature publication on this subject because I suspected a purpose to cut in with some piratical patents that might have been embarrassing — my own previous publications of inventions in automatic sprinklers, ribbed and prismatic glass, automatic fire doors, and for measuring the heat developed on heavy bearings having already saved my clients heavy royalties and obstructive litigation.

I will merely add one more element to the light that I have attempted to derive from mud. What with lignite, mud, cornstalks, sorghum, bog peat, and moss peat, we may tide over the present period of our ignorance during which we must secure light and heat from these crude materials, including coal, awaiting the invention of the perfected storage battery, by which we may soon be able to supply all our domestic fuel and light by the storage of wind, especially on the Heath Hill; while other less favored dwelling places will derive their light and heat from the fall of water or the rising of the tides.

I had but completed this analysis of the Zeigler process when in came one of the earlier graduates of the Institute to consult me on how his son, also a graduate in chemical engineering, now taking a post-graduate course in Berlin, could best introduce the Zeigler process in this country. Surely all things come to him who waits.

ADDENDUM.

At the date of correcting the proofs of the foregoing, June 4, 1903, I may record additional progress. A little group of Swedes, possessing very little money, have for five years been making a physically strong coke from the salt marsh peat of Connecticut, on one of the channels subject to the ebb and flow of

the tide. This grass peat, as it may be called, is spongy, porous, and full of roots slightly decayed, probably preserved by the salt, also containing a large amount of fine sand brought in by the tide; and yet this material is compressed and converted into a physically strong coke, which burns freely for domestic purposes, and although it contains thirty per cent. of sand its heating value is equal to sixty-five per cent. of that of good bituminous coal. Persons with capital have taken hold of this matter and will develop it.

Again, Professor Norton has made physically strong and excellent coke in the laboratory of the Insurance Engineering Experiment Station from uncompressed, air-dried Taunton River mud. Of course, the uncompressed mud being somewhat friable, the coke is delivered in small pieces from the size of a pea to the size of a walnut. When compressed, as it soon will be, we expect to make large blocks of excellent coke from this mud. As yet, the retorting process has been conducted in a piece of iron pipe, stopped at the ends, with a vent for the escape of gas. We have tested this gas with a gas burner, and find it a high-power illuminating gas, therefore capable of yielding all the secondary products of gas.

The mechanism for pulping this mud and bringing it into condition for very rapid drying is complete. Retorts will soon be adapted to our purposes, and within a short time we may be able to get an approximate estimate of converting fresh water mud into coke, gas, and secondary products.

We have now examples of mud from three points, representing bogs which, according to our minimum estimate of tolerably well-known areas and depth, contain several million tons of coke, which may be worked out from the mud at a low cost if the estimates based on laboratory experiments can be established in commercial practice.

Engineers who may have struck large bogs of mud in connection with the construction of reservoirs may perhaps ere long desire to have such deposits analyzed and reported upon. Measures will be taken to this end by Professor Norton at such charges as will reimburse the Experiment Station for doing the work.

Professor Norton suggests a very simple plan for testing any sample of marsh mud in an improvised retort :

Select a section of one and a half or two inch steam pipe, eight to twelve inches long; fill in with air-dried mud as compact as it may be made; plug the ends with clay or asbestos left loose so that the steam and gases may escape; place underneath three gas burners, Bunsen burners preferred. It might be possible to heat the contents of the pipe over the fire in an ordinary cooking stove, but the gas burners may be more readily managed. Test the burning quality of the gas at the ends when escaping.

I may suggest that it would not be a difficult matter to compress parcels of mud into cylinders of less diameter than the pipe. The coke of these compressed parcels would be in larger pieces, probably less friable than any that can be obtained from uncompressed air-dried mud.

Any person slightly conversant with laboratory practice may apply this test to deposits of mud that happen to be in the neighborhood. It is much desired that the experts in the Agricultural Experiment Stations, to all of whom this report will be sent, will test the meadow mud or "grass peat," as perhaps it had better be called, in their respective neighborhood. We shall be glad to receive reports of results, and if possible some idea of the areas and quantity that may be available for future conversion, if the processes of the laboratory can be developed in commercial practice. It is held that the area of what we have called mud bogs yielding grass peat is vastly greater than of what are customarily known as peat bogs yielding the partly decayed matter mainly derived from sphagnum moss and the water plants which grow on the surface of such bogs.

Reference may also be had to an article in the "*Nineteenth Century*" magazine for May, by Lieut.-Gen. Sir Richard Sankey, K.C.B., R.E., upon the conversion of the great bog of Arran and other Irish bogs into gas and electricity for restoring the manufactures of Ireland, many of which were destroyed by the tariff policy of Great Britain, which prevailed up to 1842, by measures corresponding to those by which the effort was made to prevent the establishment of manufactures, metal work, and the like in the colonies of America. The suggestions of Lieut.-Gen. Sir Richard Sankey are limited to the production of gas and of electric power therefrom. He does not yet appear to have

realized the possibility of making coke from the peat or mud contents of the bogs.

DISCUSSION.

VICE-PRESIDENT BROOKS. We have listened with great pleasure to Mr. Atkinson's paper, and if any member wishes to ask him any questions I am sure he will be glad to answer.

MR. CHARLES N. TAYLOR.* I was out at Lexington or at East Lexington the other day, and I noticed the pumping station which was used, I think, by Arlington before it came into the Metropolitan District; it is a very nice building, and I remarked to the superintendent of the Lexington works that it was too bad that such a nice building should be lying idle there without being put to some use. He said, "Well, they are going to use it, they are going to start a new industry here." Said I, "What is it?" He said, "You see this meadow all out through here," — that is where they had their driven wells, a large area, I should think there may have been twenty-five acres, a peat bog, it looked like, — "they are going to cut that peat and take it into the pumping station and press it into briquettes and sell it for fuel." That is the first I had ever heard of any such industry in this part of the country.

When I was in Scranton, Pa., this winter, I ran across a man with sample briquettes from Germany, and he had these reports of the United States consul to Germany and was circulating them. He was organizing a company to make briquettes of this fine waste material which comes out of the mines, and which is piled up mountains high in front of the mines, and has never been made any use of. But in reading over the report of the United States consul to Germany I thought he spoke rather discouragingly of its being a profitable scheme in this country, owing to the expense of the material which had to be put with the peat or coal dust in order to bind it together,—I think it was tar or something of that nature.

MR. ATKINSON. I am very glad to know where that undertaking is going on in Arlington, as I want very much to get some of those briquettes. The conversion of coal dust into briquettes is very common in Germany, but it requires a bonding material.

* Wellesley, Mass.

There were at one time some very large undertakings in Virginia for converting coal dust into briquettes, but for some reason or other they thought it necessary to put a little light naphtha or kerosene oil into the mixture, and on the rise in the price of naphtha their profits went out. I have come across various undertakings for getting up and introducing companies of the get-rich-quick kind in connection with this matter. Now, why I have come out prematurely is, that I want to cut off all that sort of rubbish. Mr. Norton and his assistant and myself are convinced in our own minds that we can convert this mud into briquettes of sufficient hardness and durability to be excellent fuel, by a purely mechanical process, and there is the crucial point. If we can, why then we have done it. If it requires a bonding material, there is more refuse material, tank-bottoms and the like, in this country than in any other, and we may be able to get a bonding material which is now wasted, at such an exceptionally low cost that we will be able to use it.

The main object in bringing this subject before you gentlemen is to set you all thinking about it, and to get lots of heads at work. I am nothing, as I tell you, but a "duffer," but I want to see if I can't cut off some of these piratical bottom patents on the conversion of mud. I have had to meet these piratical patents three or four times, and I have saved my clients a lot of money on sprinklers by having made an invention and publishing it a year before a patent was granted on one little element which went into all sprinklers. I smashed one piratical patent on the diffusion of light, and I am engaged to-day in smashing another because I anticipated it and published it. I have found in my practice that neither expediency nor the conditions of my profession will permit me to have any patent, and therefore we are very careful in the office to publish every little device. I invented the sliding automatic fire door which is now in universal use, and published it and got a silver medal, and had it put on record, or else I would have been cut off on that. I invented the proper way of taking the heat of a revolving shaft in the simplest possible manner and published it, and two years later a fellow came in with a patent on it and I "busted" that. My object now in this premature discussion is to cut off these get-rich-quick fellows, and start one thing on a solid basis of science and fact which has some merit in it, perhaps.

MR. FREEMAN C. COFFIN.* I don't know that Mr. Atkinson¹ is aware how appropriate this subject is for a meeting of water-works men. If we will just let our imagination loose for a few minutes we will see what can be done and what boundless possibilities are open to the water-works engineer, and how it will change the conditions under which he has got to work. We now go about the country looking for a storage reservoir, and we find a very nice place, well adapted in every way, but the mud is all the way from a foot deep to twenty feet deep, and when we find it twenty feet deep that rather discourages us. We cannot take it out at any reasonable cost, and we don't dare to store water on top of it. All we have got to do hereafter is to set up one of these little machines, — perhaps we will be able to do it next year, — make the mud into fuel, store up all the fuel the works will want to use to pump water with for years to come, and sell the balance for enough to build the works. [Laughter.]

MR. ATKINSON. You are a more visionary fellow than I am. [Laughter.]

MR. COFFIN. I am looking forward to the time when we can build water works for very much less cost than at present, and this is right in that direction. And then when we get so that by imitating Marconi we can construct our distribution system on the pipeless plan [laughter], — I don't see what there is to laugh at; it seems to me it is a very serious matter. But certainly it is going to help us on our storage basins if mud fuel turns out as we hope it will.

MR. ATKINSON. My little machine which I used at Indian Orchard and afterwards turned over to the late N. W. Farrell, and which he used for two years down at Lewiston, was a very simple one; anybody can have it made. It consisted, as I remember it, of a large cylinder about two feet in diameter, with a spiral alternating little plow shears and little knives on the straight sides, and it had a hopper at the inner edge. Then at the other end was an Archimedian screw without any knives or plow shears, and we put in an endless belt, and brought up the peat from the bottom of the bog, poured it into the hopper, turned the machine, and that ground it and pulped it and released the water. Then the Archimedian screw drove it through a three-cornered orifice. I thought it would dry a little quicker in the tri-

* Civil Engineer, Boston, Mass.

angular form than in a square; and that I had arranged so that the two top sides had a possibility of expansion in case a bit of root got in, or something too big; that delivered on an endless belt, and the peat was carried off and dried in the usual way. A most excellent steam fuel was produced. It was excellent to have in the house before I produced the Aladdin Oven, because it is the quickest breakfast fuel the cook can possibly have, and is just as good for broiling over as charcoal.

VICE-PRESIDENT BROOKS. Does anybody else want to ask Mr. Atkinson a question?

MR. CHASE. I will say that there is a chance now for fools to rush in where angels fear to tread.

MR. ATKINSON. If there is any bigger fool than the man who invades the domestic kitchen, I should like to have somebody find him for me. I want to say right on that, that through the long period of experiment in developing the Aladdin Oven, beginning in the most complex way, as roundabout as all the scientificusses do, as well as the duffers, in order to get down to ultimate simplicity, I had for five years the most intelligent coöperation of an Irish cook; and I took that Irish cook with me when they invited me on to Columbia University to give a supper to two hundred people in a building where there was no kitchen. They paid the bills and I carried on four or five ovens and that Irish cook, put her down in the basement, ordered the materials and left her there by herself, and in the evening she served an admirable nutritious supper, ample in amount and variety, to two hundred people. I could give you a better lunch than you have had to-day and cook it on the table with a couple of common parlor lamps of the round wick variety, which burn one quart of oil in eight hours.

MR. E. A. W. HAMMATT. I was somewhat interested in the remarks made about the use of peat in East Lexington. If I recollect correctly, along in the early seventies peat was handled in Lexington and put on the market.

MR. ATKINSON. Yes, it was. Peat is so important and is such a universal fuel in Denmark that the amount which may be cut in one year is limited by statute to what will be restored in the natural order two hundred years hence. It is what we don't know about fuel that I have been speaking to you about.

VICE-PRESIDENT BROOKS. I would say in connection with this subject that Nat Wyeth, who was the pioneer in cutting ice on Fresh Pond, and was also connected with the Bay State Brick Company during its early period, made at the Bay State brick yards a lot of brick to be used in the construction of the brick ice-houses which stood on the shores of Fresh Pond; and in order to make them light he mixed with the clay a large proportion of peat, and when they were burned they weighed only a fraction of what an ordinary brick would weigh. When those buildings were torn down, some fifteen years ago, the bricks which were used in the cell work, lining up the inside of the houses, were taken away and used for partition walls in some buildings down in Cambridge. They created a good deal of wonderment at the time, people not knowing how they were made and not being able to account for their extreme lightness. I believe Mr. Wyeth also attempted to burn bricks with peat, but I think it was not successful. I think that we may say of him that he coined an expression that is capable of wide application, and perhaps if more people would remember it they would not be discouraged so often at seeming failure when they attempt to do something new. Mr. Wyeth was engaged in perfecting machinery for cutting ice, and he did not hesitate to go to almost any expense upon a machine, and if a failure occurred he always used to say: "It is worth just as much to know what will not work as to know what will."

MR. ATKINSON. That is a most interesting point. Of course the philosophy of that was that the peat in the interstices of the clay was burnt out in the process of burning the brick and left globules of air, the best non-heat and non-cold conductor in the world, and you therefore had the most effective non-heat conductor that could be made of clay. I wonder that that had n't been followed up for many of my own purposes. There is a field open for it now. One of the subjects which we have had to explore to the fullest extent, a covering for steam pipes and boilers, is waiting for a porous clay. Norton has made it somewhat in imitation of tufa, but we have n't yet developed it, — the lightest and most indestructible material with which steam pipes and boilers can be covered, or it may be made in slabs. This is an extremely interesting point. I have learned something to-day and I have got something which will be developed. [Applause and laughter.]

MR. CHASE. I remember seeing a number of years ago, it must be nearly twenty, a slab of something like fire-brick which is used in bakers' ovens, which had been made by a mixture of clay with sawdust and then burned, and my impression is that that was used in the construction of a mechanical filter at Marshalltown, Iowa. I think that is where I heard of it, but I forget whether it was made there or came from New York state. I think it is now in the office in North Carolina. My impression is it was a slab about 14 by 18 and 2 and $\frac{1}{2}$ inches thick, of light brown color, and it weighed not over one third of what an ordinary bakers' oven slab of the same size weighs. It was sent to us with the idea that it could be used to strain the color out of water, but it was so porous that we found it would hardly take the bugs out.

PIPES AND PIPE LAYING FOR THE METROPOLITAN WATER WORKS.

BY CALEB MILLS SAVILLE, DIVISION ENGINEER.

[Read February 11, 1903.]

Mr. President and Gentlemen, — Under authority of Chapter 488 of the Acts of the year 1895, the Metropolitan Water Board in the latter part of that year began planning for the construction of a pipe system to distribute water to Boston and its suburban cities and towns. After the organization of the Water Board, Mr. Frederic P. Stearns was appointed chief engineer. All of the work in the Metropolitan District, including the pumping stations, the pipe systems, and the distributing reservoirs, was placed in charge of Mr. Dexter Brackett, engineer of the Distribution Department. It is concerning the pipe system and the methods of construction employed thereon that I have pleasure in inviting your attention to-day.

THE DISTRIBUTION SYSTEM.

Except in the city of Boston the consumption of water is mostly for domestic purposes, although in several of the other cities and towns there are extensive industries using large amounts of water. In the report of the State Board of Health to the legislature of 1895 it was estimated that one hundred gallons per capita would be a reasonable amount for which to provide.

The probable growth of the district was carefully estimated and this taken with the per capita consumption was used as a basis for proportioning the pipe lines.

In Boston, and in many of the cities and towns in the northern part of the district, the conditions were such as to make it advisable to maintain both high and low service systems, in order that on the one hand adequate pressure might be had on the elevated portions, while on the other hand excessive pressure and conse-

quent expense for pumping might be avoided in the low parts. A most comprehensive scheme for supplying the district with water had been laid out in the State Board of Health Report for 1895. The plans there suggested, while generally followed, were elaborated and developed as detailed investigations and surveys were made for the actual work. With Chestnut Hill Reservoir and the pumping stations as a center, two 48-inch pipe lines run in a general northerly direction to Spot Pond, supplying low-service water on the way to Arlington, Somerville, Medford, Malden, Everett, Chelsea, East Boston, and Charlestown. These lines follow different routes, one passing through the westerly parts of Cambridge, Somerville, and Medford; the other through the easterly parts of these cities and through Malden and Melrose. From Malden a branch from this latter line runs off to Everett, Chelsea, and East Boston. From the same center two more 48-inch lines run easterly for the low-service supply of Boston; 48-, 36-, and 30-inch lines run southerly for the high-service supply of this city, and for the whole supply of Quincy and Milton. Westerly a 36-inch main carries the supply of Watertown and Belmont, with provision for the future supply of Newton. The high service supply of the towns and cities in the northerly part of the district, and the entire supply of Stoneham, Revere, Nahant, Swampscott, Melrose, and Winthrop, is pumped from Spot Pond into the High-Service Reservoir* in Middlesex Fells.

At the same time that surveys and investigations were being made for location, studies, plans, and contracts were made for the pipes, specials, valves, and other appurtenances for the pipe lines. The pipes † and special castings were made substantially according to the standard specifications for cast-iron pipes reported in the JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, Vol. 16, p. 330. For the storage of these materials on their arrival and for convenience in sending them out, land was acquired temporarily or permanently for pipe-yard purposes as conveniently located as possible with reference to the proposed work and to the railroads. In the pipe yards the pipe is stored

* Paper on Fells Reservoir, by Mr. J. L. Howard, Division Engineer, Metropolitan Water Works, JOURNAL NEW ENGLAND WATER WORKS ASSOCIATION, vol. xv, p. 20.

† Paper by Mr. Dexter Brackett, Engineer Distribution Department Metropolitan Water Works, JOURNAL NEW ENGLAND WATER WORKS ASSOCIATION, vol. xlii, p. 325.



FIG. 1. — METROPOLITAN PIPE YARD, SOMERVILLE.



FIG. 2. — 48-INCH PIPE LINE FLOATED BY WATER USED IN PUDDLING.

on spruce runs in tiers to a height of about 12 feet. It is handled by a 55-foot boom derrick of 10 tons capacity, held in place by five 1½-inch wire guys fastened to "deadmen," and rests on a block of concrete 4 feet thick and 4 feet square. As it was necessary to have a certain number of men in the pipe yard, it seemed best to operate the derricks by hand power rather than steam. Plate I, Fig. 1, is a view of the Somerville pipe yard.

APPURTENANCES AND SPECIAL DETAILS.

On pipes 30 inches diameter and larger, manhole pipes for affording entrance to the inside of the pipe line were placed at convenient intervals. These pipes were special castings about 3 feet long with bell and spigot ends, having a flanged circular opening in the top, on which was bolted a cast-iron cover with a gasket between. All gate valves of 12 inch and larger were made from patterns specially designed for this work, owned by the Board and loaned to the maker. The iron castings are made from superior quality metal and thoroughly tested for their work. The composition castings are made of new material of the best quality, the valve seats and faces being 3 parts copper and 1 part zinc; all other composition is of 88 parts copper, 10 parts tin and 2 parts zinc, having a tensile strength of not less than 30 000 lbs. per square inch. Each valve has the maker's initials and the year cast on the outside of the dome. The seats and faces are faced with composition inserted in a dovetailed groove, solidly hammered in and fastened with brass or composition screws. Before delivery the valves are tested at the contractor's expense as follows: First, heads are secured at each end of the casting, the valves opened and a pressure of 250 lbs. per square inch applied; second, the face joints of the valves are tested by closing the valves, leaving one end of the casting open and applying a pressure of 150 lbs. per square inch to the other; this operation is then reversed and the other face of the valve tested.

All of the gate valves except a few near the pumping stations are operated by hand power. This method insures slow closing and is a safeguard against ram. At the pumping stations, however, hydraulic power is used to operate the large valves in the mains which are most often used. No valves larger than 36 inches in diameter have been used, reducers, making a section like

a venturi meter with a 36-inch valve at the throat, being placed on the larger-sized pipes. This method greatly reduced the cost, and inappreciably affected the head.

A number of check valves have been used on the system, which, while generally following usual types, are, like the gate valves, made from specially designed patterns.

Two sizes of air valves are used, one having a gross opening in the shank of an inch diameter, the other of $1\frac{1}{2}$ inches. These valves are not self-acting, but require to be both closed and opened by operating a screw in the stem, a shield around the upper portion of the valve protecting the operator from water when the air is driven from the pipe. The advantages of this style valve are that it is positive in its action and, on account of proximity to the pipe, unlikely to freeze.

In several places where the pressure afforded by the Metropolitan mains is higher than necessary for the supply of the town, reducing valves, either of the Ross pattern or a specially designed balanced valve, are used to reduce the pressure on the local connection.

Where a joint opening of less than one inch would be required, changes in direction were made with 12-foot lengths of straight pipe. Changes in direction requiring sharper curvature than this were made with specially cast pipes. Whenever these special castings were used, the joints were run solid with lead, and the pipes solidly backed with concrete.

Lugs were cast on all branches, and the cap or gate controlling the opening securely bolted to the main line. In laying the pipes under several reservoirs, provision was made against the tendency for the outside water pressure to float the pipes if empty by fastening them to concrete blocks by iron straps encircling the pipe. All summits where air might collect are furnished with air valves, and all low places, where possible, have blow-off branches for draining the line.

The specifications for the pipe-laying were drawn with the greatest care, and the consensus of opinion among contractors seems to be that the signing of a Metropolitan pipe-laying contract is equivalent to giving a quitclaim deed. However this may be, no lawsuits have been necessary in settling claims since the beginning of the work.

CONSTRUCTION WORK.

The lines of the trench in streets followed as closely as possible established street lines, and where practicable such a location was chosen that the pipe line would neither be under street car tracks in the center nor in the location of surface drains in the side of the roadway. Alignment was given by spikes driven on a convenient offset and at intervals of about fifty feet on tangents. Spikes were also driven on all points of curvature and at short intervals on curves. These spikes were leveled over and grades given on them which were afterwards transferred to grade boards set up over the center of the trench. Few sewers can show better lines and grades than those in the pipe lines of the Distribution Department.

The pipes were hauled to the trench by the contractor, being delivered on his teams at the pipe yard by the Commonwealth. In the case of the larger sizes of pipes, it was soon found most convenient to use teams made specially for the work. After delivery the contractor was responsible for all materials until the pipe line was accepted and the final payment made. This provision was rigidly enforced, and resulted in much greater care being taken of the materials. As it was, almost every final estimate contained a deduction for broken pipes and small articles lost or stolen.

In excavating the trenches care was taken to interrupt traffic as little as possible, and the trenches were bridged at short intervals to accommodate foot travelers.

The road metal or other surfacing material was first stripped and carefully saved to be replaced.

As a general thing it was intended to lay the pipes so that the axis would be about five feet below the surface of the ground. This necessitated very many changes in water-service pipe and in some cases both sewer and gas connections also. Where large pipes were to be laid it seemed best to hold to the line and grade and change existing structures. In the central parts of the older towns and cities many structures were encountered, as water and gas pipes, sewers, drains, and catch basins. Those recently built were fairly well located, and the plans were made to avoid them as far as possible. The older structures were usually not only

without recorded location, but in many cases out of the memory of the oldest inhabitant, even as to utility.

In some cases most obstinate worship seemed to attach to some old structure like a fire cistern dating from the time of the old hand engines and of a size that the modern engine would exhaust in fifteen minutes. No amount of diplomacy was usually sufficient to obtain permission to fill these up, and offsets had to be made in the pipe line or expensive measures taken to ensure the permanency of the basin and protection of the main if by any great favor it was permitted to lay the pipe through the walls.

In several places the existing location of the sewer was such that the pipe line was carried deep down below everything. In the case of small-sized pipes this method was much less expensive than the relocation of the many service pipes in thickly-settled communities. When existing sewers and drains were found in locations where it was impossible to change the pipe line or the house connections, parallel sewers were laid to take the drainage. The irresponsible way in which the older lines of gas pipes meandered from side to side of a well-laid out street was a thorn in the side of the locating engineer, and suggested that the same surveyor had perhaps been employed who laid out the older streets of Boston.

In a number of instances the pipe lines passed through streets built over soft and marshy ground. If the depth of soft material was great a pile foundation was used; if it were only a few feet, concrete piers were substituted for the piles; and if only of very shallow depth the material was entirely excavated, and the grade of the pipe line lowered or the trench filled with suitable material up to the proposed grade, and the pipes laid on the new foundation. In places where much mud was encountered, every precaution was taken to backfill entirely around the pipe and for six or eight inches over its top with clean gravel before any of the mud was replaced.

Where the material was suitable, water was used for settling it back again into the trench. The use of water for this purpose caused considerable discussion with contractors. Some claimed that the proper method was to almost entirely fill the trench with earth and then flood with water, using a long bar to

make holes in the filling and allow the water to settle. Others preferred to fill the trench perhaps one third full of water and allow the material to settle through this into place. Still others combined the two methods by keeping a large hose stream continually on the backfilling material. All of these methods have their good points, and the best for any particular place depends upon the nature of the material. In using water to backfill great care should be taken with the larger sizes of pipes to prevent floating the empty pipe line. One or two instances of this happened where a 48-inch pipe line was raised and thrown out of alignment for a considerable distance from this cause. (See Plate I, Fig. 2.) This line was forced back into position and the joints recalked. In macadamized streets the trench was first filled to subgrade of the roadway, and then the best portions of the surfacing materials screened and deposited in layers, the largest size being replaced first, and the remaining materials in layers according to their size. The whole trench was then wet and rolled with a steam or heavy grooved roller.

With the larger sizes of pipe there was usually some surplus which if good gravel or sand was readily disposed of. The cities and towns where work was under way were given the first opportunity to secure it. In some of the trenches for pipe twenty inches and under there was no surplus, and the contractor was obliged to haul material from elsewhere to fill portions of the trench.

In cutting the pipes it was found best to mark entirely around first with a diamond point on the outside, and if the pipe was large enough to enter, on the inside also, before beginning with the dog chisels. In this manner very clean cuts were made and few pipes broken.

In jointing the pipes either canvas or steel jointers were used, the former being preferred. The joints, except in few cases, were all run from the top and filled by continuous pouring. If any joint failed to fill, it was usually dug out, melting not being allowed, except for some extraordinary reason.

When a pipe was lowered into the trench it was lined and graded by the inspector, and pairs of wedges driven home in two places underneath. After the joint was yarned, the inspector tried the depth of the lead space with a gage, and, if satisfactory,

the joint was poured. As soon as possible after the joints were made they were covered, to prevent the lead being drawn out by expansion and contraction of the iron, if exposed to the sun. The pipes usually were placed in the trench by a derrick, operated by hand and spanning the trench. In the case of the line on Commonwealth Avenue, Newton, however, where a 15-foot trench was excavated through the rock to accomodate a future line, the pipes were rolled sidewise down an incline and placed by a tackle hung to an overhead beam.

At two brook crossings, each about fifteen feet wide, where it was undesirable to go below the bed, and unwise to contract the water-way by passing a large pipe through it, the grade was carried so that the top of the pipe was about a foot from the street surface and protected against damage from steam-roller or street-car weight by a curved steel plate supported by I-beams on either side of the pipe. Stony Brook, West Roxbury, was crossed by a self-supporting 36-inch steel pipe 38 feet long.

Usually the pipes were laid uphill, breaking the line when the summit was reached and beginning again at the bottom. This was especially necessary in the larger and heavier pipes, to ensure getting the spigot home in the bell.

Where there were no bridges, railroad tracks were crossed under by an open trench, the tracks being temporarily supported by large timbers placed by the railroad at the expense of the contractor. Several streams and railroads were crossed, either by hanging the pipes to the iron stringers of the bridges and building around them boxes sufficiently tight to protect from frost, or by supporting the pipe on top of the bridge beams.

It is remarkable what slight protection will prevent freezing if sufficiently tight to shut out drafts. The 12-inch pipe supplying the high portions of Milton in making a crossing 115 feet long at West Street, Hyde Park, is protected only by a steel plate $\frac{1}{4}$ -inch thick on the bottom, 8-inch I-beams on the sides, and 4-inch planking on top. With a flow of about six gallons per minute, the water in this pipe did not freeze during the coldest nights of this winter. In Medford the 20-inch and 48-inch pipes are carried over Mystic River in a plate girder bridge resting on stone abutments.

On only two pipe-laying contracts have attempts been

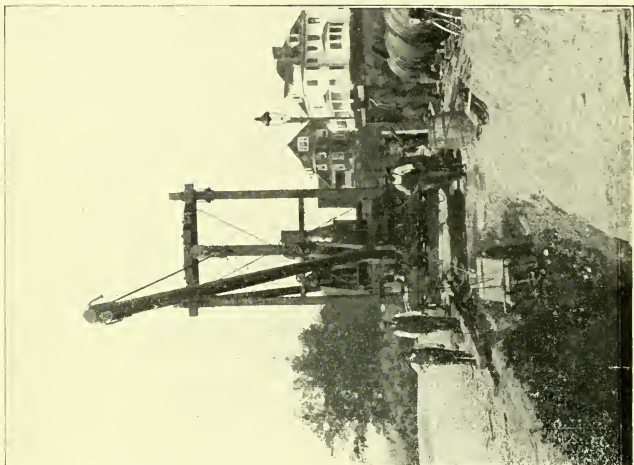


FIG. 1. — BYER TRENCH MACHINE, USED ON SECTIONS 19 AND 24.

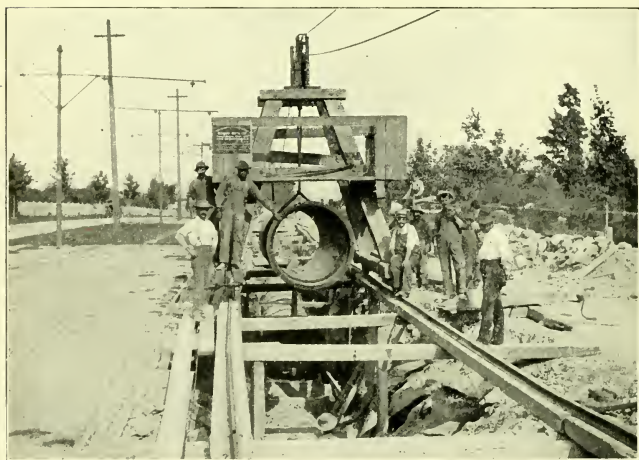


FIG. 2. — MOORE TRENCH MACHINE, USED ON SECT. 4 SUPPLY PIPE LINES.

made to use machinery either for excavating or pipe laying, although steam derricks have been used in a number of places where the nature of the work required a considerable excavation and much pipe laying in a contracted area. A steam excavating machine was used somewhat by E. W. Everson & Co. on Section 19, in a gravel trench, but with indifferent success; and later this same machine was used in excavating for the laying of a 20-inch pipe under Charles River between Newton and Watertown. This machine, which is shown in Plate II, Fig. 1, consisted of a double-drum hoisting engine, mounted on a platform which also carried a boom derrick on a turntable. This platform rested on flanged wheels running on T-rails. By means of "deadmen" and ropes attached to the engine drums, the machine could be drawn forward or backward on the rails. Attached to the boom of the derrick was a bucket similar to that used in a dipper dredge, and by means of wire ropes and an anchor this bucket could be pulled some distance from the engine, dropped into the trench, and when pulled back would be filled with material from the trench bottom. When the engine was reached the bucket could be hoisted by the derrick, turned to one side, and dumped alongside the trench.

On Section 4, Supply Pipe Lines, a machine designed by the contractor, Thomas F. Moore, was used which was very satisfactory in its working, and apparently effected considerable saving over hand methods both in trenching and pipe laying. (See Plate II, Fig. 2). Usually when a large pipe is laid through a narrow street it is necessary to close that street to travel, to the great annoyance of the public. Beside this, the contractor himself must arrange to have all his pipes hauled on to the ground before the street is closed. The excavated material is piled high in every available place, to the damage of lawns and fences, no matter what care is taken. With this machine there is no material stored alongside the trench, except the surfacing of the roadway. The material from the head of the trench is shoveled into buckets by laborers, hoisted by the cable, run backward, and dumped over the pipe laid at the other end of the trench. The buckets have hinged bottoms, and the load can be dumped either from the cableway without stopping the machine, or the buckets can be lowered into the trench, the bottom of the bucket opened

and the load released simply by raising the bucket. This feature is of great importance when handling materials in which there are stones or other solid matter, which it would be unsafe to drop on the unprotected pipe.

In laying 48-inch pipes with this machine, only about 11 feet in width of roadway and from 150 to 200 feet in length is occupied. In a narrow street the pipes need not be stored alongside the trench, but can be laid as soon as brought to the ground, and no time lost to the pipe-laying gang as would usually be the case. The pipe is dropped alongside the trench where convenient, and rolled under the cableway on to timbers over the trench. It is then pulled up by the travelling carriage, taken to the proper point, and lowered into place. The usual tedious work of forcing the pipe into place with bars is avoided, the pipe being snubbed home and held there by the machine until received by wedges at the required grade. Two men in the car and the engineer take the place of the subforeman and derrick gang usually employed.

Considerable rock work has been necessary in trenching for the pipe lines, some of the heaviest work being done during the past year in excavating for a 60-inch line in Medford and for 48-inch lines in Newton. Plate III, Figs. 1 and 2 show a rock trench on Commonwealth Avenue, Newton, previous to laying pipe and after one line was laid. In the future it is expected to lay lines parallel to both of these, and at this time enough rock was excavated so that hereafter no rock work would be necessary in these places.

A number of long, and in some cases difficult, river crossings have been made on the work, and the methods employed varied considerably. Two crossings of the Charles River, Cambridge, and of the Mystic River, Medford, were made with double lines of 36-inch pipes, connected with a single 48-inch line at each end by a Y-branch. These pipes were laid in six-pipe sections, the spigot end of the section to be laid being specially cast with a taper to fit into a leaded joint in the bell of the section previously laid. The sections to be laid were fastened to a truss on the side of a pipe-laying scow, and could be raised or lowered as required.* When at the proper point the pipe section on the

* A more detailed description of the submerged pipe laying may be found in *Journal Assoc. Eng. Soc's.*, Vol. XXVI, 1901, p. 193.



FIG. 1.—ROCK TRENCH READY FOR 48-INCH PIPE.



FIG. 2.—ROCK TRENCH WITH 48-INCH PIPE.

truss was forced home by hydraulic pressure, a diver guiding the spigot end into the receiving bell. After being laid, all joints were recalked by the diver. Changes in direction were made with ball and socket joints having a maximum deflection of 1: 10. The trench across the river was previously dredged for the pipe, and in the case of the Mystic crossing a pile foundation was used for the entire distance.

At the Malden River a double line of 36-inch pipe was laid in a coffer dam, one half of the work being done and the dam removed before work was begun on the other half. The Saugus River, Lynn, was crossed by pipes laid in a double wooden frost box, supported on a pile foundation as far as the channel, and this by means of an inverted siphon. This was 45 feet between the vertical legs, and the top of the horizontal portion was about 21 feet below mean high water. It was built of hard pine timber, 6 inches thick, thoroughly bolted and keyed together, making a box 4 feet 8 inches by 3 feet 8 inches over all, inside of which was placed a 20-inch pipe surrounded by Portland cement concrete. At Mystic River between Medford and Arlington, where the water was shallow, a sand-bag dam and close sheeting was used to lay a 20-inch pipe with ordinary joints. At Charles River, between Newton and Watertown, as mentioned above, a machine was used for excavating and handling the pipes. The material excavated was piled around a section about fifty feet long, which when the tide was low could be pumped clear of water and the pipe laid. On the return of the tide, backfilling would be done and further excavation. The rise and fall of the tide being only a few feet, work of this nature could proceed at any time.

For the supply of East Boston a 24-inch pipe with spherical joints was laid under Chelsea Creek. Previous to this the supply had been carried by two pipe lines, one 20 inches and the other 24 inches in diameter. The 24-inch line was laid in 1871, with pipe similar to those above described. The 20-inch line was laid in 1850. Below low water these pipes were laid in three-pipe sections, each pipe being 9 feet long and having flanged joints. At the end of each section was a curious swivel joint, allowing the freest possible motion vertically, but being rigid to horizontal movement. These joints made a series of right-

angled offsets in the pipe line, which must have resulted in a considerable loss of head. After removal, the pipes both above and below water were found to be very badly tuberculated, the inside diameters being reduced as much as two inches by a solid mass of incrustation. The pipes of this line above low water originally had their walls $\frac{7}{8}$ inch in thickness, but the whole barrel was somewhat reduced, and in places the iron was so soft that $\frac{1}{4}$ inch could be dug out with a pocket knife. Below low water the pipes were $1\frac{3}{4}$ inches thick, and had been covered with clay. Where this material was solidly bedded about the pipe the protection was perfect, even the rope slings used to lower the pipe being found attached when the pipe was raised. The new line was made up with 24-inch pipes, having ball and socket joints similar to those used with the 36-inch pipes at the Mystic River. The line below low water was wholly composed of these pipes, which were laid from a curved slide on the side of a pipe-laying scow. One end of the line was securely anchored on one side of the river and other pipes put into the slide, the joints leaded, and the pipes pulled down the slide to the river bottom by warping the scow ahead.

Under Mystic River at Chelsea North Bridge, two inverted siphons of the pattern used at Saugus River, but containing pipes of 30 inches and 24 inches respectively, had been laid, the first in 1850 and the second one in 1864. On account of the widening and deepening of the channel and reconstruction of the draw at this point, it was found necessary to replace these pipes. Both lines were badly tuberculated, being reduced in diameter from $2\frac{1}{2}$ to 4 inches. The 30-inch pipes were of Scotch make, $\frac{7}{8}$ inch thick, having bells with joint room $6\frac{1}{2}$ inches deep and $\frac{3}{8}$ inch wide, run solid with lead. Both of these pipes had been covered with concrete boxed with heavy timbers, and the 30 inch siphon copper sheathed on the uprights. All the bolts in the latter siphon were of copper, and were in excellent condition. The other box was put together with iron bolts, which were badly deteriorated except in the bottom. This portion had been covered with clay, and was in good condition. Both boxes where exposed between the river bottom and low water were almost wholly destroyed by limnoria.

Although Chelsea and East Boston were now supplied by a

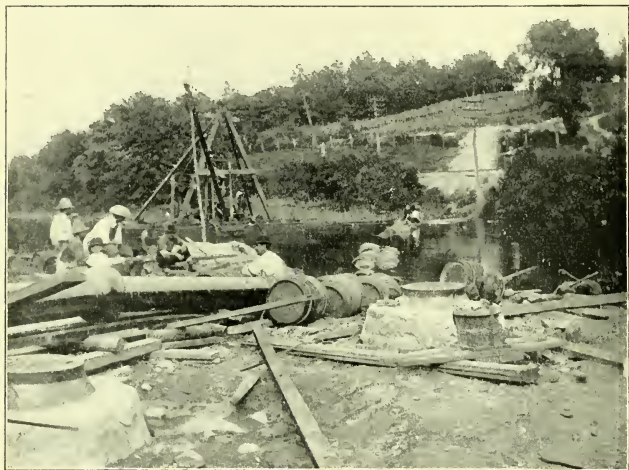


FIG. 1. — LAYING 12-INCH PIPE ACROSS NEPONSET RIVER.

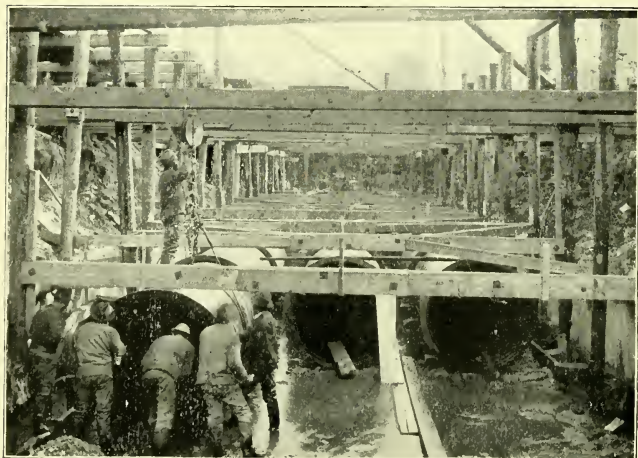


FIG. 2. — LAYING 3 60-INCH PIPE LINES IN COFFER DAM
UNDER CHARLES RIVER, NEWTON.

42-inch pipe recently laid, it seemed best to still maintain a supply in this location. The greater depth and breadth made the use of a siphon impracticable, and a tunnel 6 feet in diameter and 145 feet in length was constructed, having a shaft on either side of the channel, in which a 24-inch pipe line was laid and connected with the pipe previously in service on either side. About 45 feet of each shaft is composed of steel cylinders 8 feet in diameter, made of $\frac{1}{2}$ -inch plates, three 9-foot lengths of cylinder being set up on the deck of a lighter and partially lined with brick masonry. This portion was then lowered into position and allowed to settle, necessary sections being added at low water to bring the top well above the highest tide. On top of this cylinder an air lock was bolted, and the work proceeded by means of the ordinary methods used in pneumatic work. In both shaft and drift circular wooden lagging was used, forming a solid wooden ring 5 inches thick outside the brickwork.

At the Neponset River in Hyde Park a 12-inch line made up of pipes with ball and socket joints was used. These pipes were floated into position over a dredged trench by means of oil barrels securely lashed to the pipes, (see Plate IV, Fig. 1) and when all was ready these were cut away and the pipe allowed to settle into place. A subsequent test of this line indicated that it was almost bottle tight.

The Charles River between Newton and Weston is being crossed by three parallel lines of 60-inch pipes covered with concrete. This work is being done by means of a coffer dam. (Plate IV, Fig. 2). The river and flats, which are at times under water, made it necessary to work in the coffer dam for about three hundred feet. The maximum depth of the water is about seven feet, and the bottom of the pipes in the channel about seven feet below the river bed. The coffer dam is a two-story structure, the upper part above the river bed being fifty feet wide in the clear and having double walls of 4-inch tongued and grooved spruce sheeting. The double walls are five feet apart, and filled in with sand and mud from the excavation. Inside this dam a trench 25 feet wide, sheeted with 3-inch by 9-inch spruce timber, is dug in the river bottom to a depth of about seven feet at the center of the channel and fourteen feet deep near shore. In this trench the pipes are laid. The material encountered was sandy gravel, containing

considerable water, as much as six million gallons being pumped per day by the 6-inch and 8-inch centrifugal pumps.

An interesting feature of this work is the running of the joints solid with lead and the calking of the lead joints both on the inside and outside. For this work no gasket was used in the joint, but a band of steel $2\frac{1}{2}$ inches wide, $\frac{3}{16}$ inch thick, and the length of the inside circumference of a 60-inch pipe was made up in circular shapes, fitted against the inside of the joint, and held securely in place by bolts and nuts, placed in such a manner that by screwing them up the steel band would be expanded against the pipe walls in the same manner a pair of calipers are opened. When the joint was run, men would calk the inside of the joint as well as the outside, thus making a smooth and tight joint. On previous 60-inch lines the joints had been pointed with Portland cement mortar on the inside.

After the pipe lines are completed, and before being accepted, they are tested by such hydrostatic pressure as seems desirable. The pressure is usually obtained by a hand-power force pump, taking water from a nearby hydrant and delivering it through a meter into the pipe line through a hole tapped for an air valve.

After the construction work is all done, record plans (Fig. 1) are made up showing the general location of both plan and profile to scales of forty feet and four feet to the inch, horizontally and vertically, respectively. Record detail plans (Fig. 2), are also made to a scale of twenty feet to an inch, showing all valves and appurtenances that it might be necessary to locate quickly.

COST OF PIPE-LAYING WORK.

Table No. 1, page 220, shows the total cost to the Commonwealth of laying several pipe lines of various sizes. On account of lower prices both for materials and labor previously prevailing; this work cost much less than would similar work to-day.

Table No. 2, page 222, shows the prices bid by contractors for laying pipes from the beginning of work to the present time. In making up the average shown in Column 6, a few have either a very high or a very low bid omitted. This was done because it seemed that the judgment of the great majority of bidders was a more reliable estimate of the amount that should be received for the work, and extreme prices either were errors or indications

of an unbalanced bid. For the 48-inch pipes, of the 119 bids received, only 14 were rejected as being either too high or too low for a well-considered offer.

The bids under Contracts 30, 64, and 207 are large on account of the long haul for materials and location difficult of access. Under Contract 39 for laying 30-inch pipe, if the two highest bids were omitted the average of the others is \$1.20 per linear foot. Under Contract 60 the bids for the 42-inch pipe were high on account of long haul and location, which was in narrow city streets containing many underground obstructions.

Table No. 3, page 223, is presented as an individual opinion of what, under ordinary circumstances and average conditions, pipes of the several sizes listed might be laid for under contract work at the present time. It is generally based on the foregoing information and on data collected during the work of construction. If used it is expected to serve as a guide, and is not a statement of the cost of pipe laying under any and all conditions.

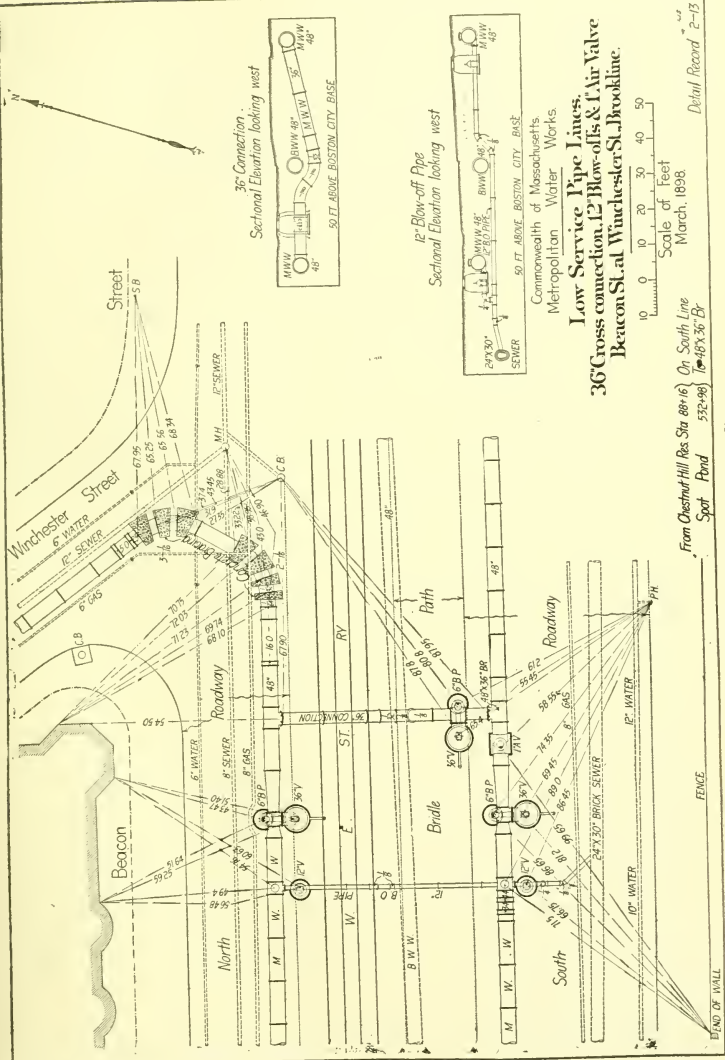
BASIS OF COST TABLE.

<i>Pipes, etc. —</i>	<i>Average per cent. of cost of straight pipe.</i>
Small pipes (for blow-offs and connections)	1.50
Special castings	4.50
Valves	5.00
Miscellaneous materials	1.00
Total percentage to be added to the cost per ton of straight pipe	12.00

The heading Miscellaneous includes frames and covers for chambers, and payments for labor and miscellaneous materials not included elsewhere.

When pipe is \$26.80 per ton, the cost per ton of the pipe line, including small pipes, specials, valves, etc., would be \$30.02 (26.80×1.12). Thirty dollars per ton is used in the cost table, as the average cost of straight pipe recently purchased was in the neighborhood of \$27.

Teaming. — The cost of teaming pipe on 21 contracts previous to 1898 was \$0.26 per ton per mile, and the average haul from the pipe yards was 2.4 miles. In the above table \$0.30 per ton per mile is used, with an average haul of $2\frac{1}{2}$ miles.



TABLE

ACTUAL COST TO METROPOLITAN WATER
EXCLUSIVE OF EXPENSE FOR

Year Laid	Section.	Diam. Pipe. In.	Length of Section. Feet.	Pipes, Specials, Valves, and Manhole Covers, etc.		CONTRACT			
						Earth Excavation and Refilling, Pipe Laying, Building Chambers, etc.		Rock Excavation.	
				Cost.	Cost per Foot.	Cost.	Cost per Foot.	Cost.	Cost per Foot.
1896-7	4	48	18 804	\$152 887 80	\$8 07	\$49 576 98	\$2 64		
1896	2	48	20 354	140 309 03	6 89	39 517 92	1 94	\$1 818 00	\$ 0 09
1896	7	48	13 630	95 092 33	7 02	36 809 13	2 70	4 146 50	0 31
1897-8	9	48	11 968	85 276 33	7 15	20 722 15	1 73	496 00	0 04
1896-7	11	48	15 102	101 746 36	6 73	41 619 46	2 77	1 402 50	0 09
1897-8	19	48	18 118	129 917 57	7 16	42 830 92	2 36	5 344 50	0 29
1897	13	36	11 141	55 836 01	5 01	26 537 44	2 38	11 205 00	1 00
1898	20	36	17 413	79 729 45	4 57	25 644 82	1 47	3 007 92	0 18
1897	23	36	8 317	32 775 25	3 94	9 895 24	1 19		
1896	14	30	7 231	27 969 64	3 86	7 918 84	1 09	950 40	0 13
1896	15	24	4 252	10 260 91	2 41	3 712 71	0 87	127 75	0 03
1897	21	24	15 412	35 395 47	2 29	13 462 66	0 87	336 00	0 02
1896	15	20	9 742	19 285 80	1 98	7 774 96	0 80	36 02	0 003
1897	24	20	11 537	19 818 81	1 72	10 392 10	0 90		
1896	16	16	10 108	13 165 95	1 30	4 704 59	0 47	18 30	
1898	26	16	18 246	23 921 48	1 31	10 556 04	0 58	15 00	
1898	27	16	11 255	13 816 08	1 23	7 067 09	0 63	21 20	
1898	25	16	5 010	6 607 75	1 32	2 465 76	0 46	29 10	
1898	16	12	3 880	3 576 30	0 92	2 374 48	0 61	0 75	0 00
1902	30	12	8 625	10 624 73	1 23	5 625 38	0 65	320 90	0 03
1898	27	12	3 067	2 712 63	0 88	1 444 76	0 47	112 00	0 03

No. 1.

WORKS OF LAYING WATER PIPES.

ENGINEERING AND INSPECTION.

WORK.		ADDITIONAL ACC'T.		Total Cost per Foot as Laid.	Average Cost per Linear Foot.	REMARKS.
Extra Work, Change in Location, Pipes, etc.	Expense for Labor and Materials not otherwise included.					
Cost.	Cost per Foot.	Cost.	Cost per Foot.			
\$158 35	\$0 01	\$11 042 11	\$0 61	\$11 32	}	City streets, either paved or macadamized.
		3 385 98	0 16	9 08		Macadamized roads and bridle path of boulevard.
2 243 31	0 16	4 960 95	0 36	10 08		Macadamized and gravel roads.
1 501 29	0 13	2 645 20	0 22	9 10	\$10 10	Macadamized streets.
1 567 45	0 10	11 217 69	0 75	11 28		Macadamized streets.
2 637 49	0 15	6 000 03	0 33	9 85	}	Macadamized streets, gravel roads and bridle path.
1 600 39	0 14	1 952 16	0 17	7 56		Macadamized streets, gravel roads and unbroken woodland.
2 021 16	0 12	1 376 45	0 08	6 42		Macadamized streets.
		1 204 27	0 14	5 27		Macadamized city streets.
2 890 57	0 40	3 181 98	0 44	5 92	5 90	Macadamized city streets.
77 06	0 02	189 68	0 04	3 37	}	Macadamized city streets and gravel roads.
2 733 48	0 18	2 533 26	0 16	3 52		Macadamized city streets and gravel town roads.
274 79	0 03	442 60	0 05	2 86		Macadamized city streets and gravel town roads.
		3 315 65	0 29	2 91	}	Gravel town roads and mac- adamized streets, excluding cost of 840 lin. ft. approaches and 310 lin. ft. under Charles River, cost \$7 721 24.
202 22	0 02	487 29	0 05	1 84		Gravel town roads.
1 022 64	0 06	3 503 85	0 19	2 14	}	Gravel town roads, and includ- ing three stream crossings on highway bridges.
2 475 61	0 22	3 776 90	0 38	2 46		Paved city streets, many local obstructions.
168 48	0 03	638 45	0 13	1 94		Gravel town roads.
71 89	0 02	208 84	0 05	1 60	}	Gravel town roads.
342 53	0 04	1 698 35	0 20	2 15		Gravel town roads, excluding cost of 146 lin. ft. laid under Neponset River, \$2 003 51.
80 00	0 03	1 003 98	0 33	1 74		Cost was increased by price of c. i. pipe being 40% higher than other contracts.
						Paved or macadamized city streets.

TABLE No. 2.

PRICES BID FOR LAYING WATER PIPE—METROPOLITAN WATER WORKS.

Date.	1. Contract No.	2. Number of Bids.	3. Diam. Pipe. Inches.	4. Highest Bid.	5. Lowest Bid.	6. Average of Bids.	7. General Average.
1898	111	3	12	\$0 73	\$0 56	\$0 67	
1898	134	4		0 75	0 45	0 60	
1902	239	4		1 15	0 53	0 71	\$0 66
1896	41	11	16	0 89	0 45	0 65	
1897	58	10		0 95	0 47	0 68	
1898	133	10		0 85	0 53	0 68	
1898	134	4		0 80	0 65	0 72	0 68
1896	29	4	20	1 33	0 73	0 96	
1896	42	13		0 96	0 62	0 78	
1897	77	16		0 95	0 59	0 69	
1898	113	5		3 00	0 73	1 11	
1899	155	14		1 50	0 60	0 91	
1901	207	6		1 95	1 08	1 40	0 97
1899	155	14	24	1 80	0 60	0 97	
1901	207	6		1 95	1 25	1 47	
1896	29	4		1 47	0 83	1 09	
1897	79	12		1 15	0 68	0 87	1 10
1896	39	8	30	2 27	0 92	1 42	1 42
1896	30	4	36	1 90	1 38	1 67	
1897	64	19		2 65	0 98	1 55	
1897	70	14		1 85	1 06	1 36	
1898	109	11		1 89	0 98	1 18	1 44
1897	60	10	42	3 30	1 30	2 25	2 25
1897	60	10	48	3 34	1 60	2 27	
1896	30	4		2 35	1 92	2 08	
1896	31	6		2 60	1 79	2 28	
1896	33	5		2 73	2 24	2 57	
1897	58	10		3 85	1 81	2 28	
1897	59	13		3 45	1 63	2 19	
1897	66	15		3 24	1 25	2 08	
1897	71	13		2 37	1 70	1 97	
1897	75	6		2 68	1 55	2 05	
1897	92	9		3 10	1 49	1 97	
1898	114	3		2 75	1 85	2 18	
1898	124	5		2 25	1 80	1 93	
1902	231	7		4 05	2 21	2 43	
1902	235	6		3 25	2 21	2 54	
1902	237	7		3 35	2 19	2 61	2 23
1898	112	7	60	5 20	2 26	3 40	
1902	251	6		9 00	3 25	3 91	
1902	240	7		3 50	1 80	2 99	3 40

NOTE.—Prices given in this table are those bid for laying water pipe, and do not include rock excavation, building chambers, or extra work. Earth excavation, refilling, and pipe work are included.

TABLE No. 3. COST OF PIPE AND LAYING PER LINEAR FOOT.

Size of Pipe, Inches.	Weight per Length, Pounds.	Weight per Linear Foot, Tons (2 000 lbs.).	Cost @ \$30.00 per Ton.	Teaming, 30c. per Ton mile. Haul $2\frac{1}{2}$ miles.	Lead, 5c. per pound.	Miscellaneous Expenses.	Labor.	Cost of Laying.	Total Cost.
12 A E	810 1 010	0 034 0 043	\$1.02 1.29	\$0.025 0.035	\$0.100 0.100	\$0.065 0.065	\$0.45 0.46	\$0.64 0.66	\$1.66 1.95
14 A E	1 010 1 310	0 042 0 055	1.26 1.65	0.030 0.040	0.120 0.120	0.070 0.070	0.46 0.47	0.68 0.70	1.94 2.35
16 A E	1 215 1 610	0 051 0 067	1.53 2.01	0.040 0.050	0.130 0.130	0.070 0.070	0.50 0.51	0.74 0.76	2.27 2.77
18 A E	1 400 1 910	0 058 0 080	1.74 2.40	0.040 0.060	0.150 0.150	0.080 0.080	0.56 0.58	0.83 0.87	2.57 3.27
20 A E	1 610 2 260	0 067 0 094	2.01 2.82	0.050 0.070	0.180 0.180	0.090 0.090	0.61 0.64	0.93 0.98	2.94 3.80
24 A E	2 050 3 000	0 085 0 125	2.55 3.75	0.060 0.090	0.200 0.200	0.110 0.110	0.70 0.73	1.07 1.13	3.62 4.88
30 A E	2 820 4 340	0 119 0 181	3.27 5.43	0.090 0.135	0.250 0.250	0.130 0.135	0.78 0.83	1.25 1.35	4.52 6.78
36 A E	3 800 5 900	0 158 0 246	4.74 7.08	0.120 0.185	0.300 0.300	0.140 0.145	0.88 0.93	1.44 1.56	6.18 8.64
42 A E	4 920 7 720	0 205 0 322	6.15 9.66	0.155 0.240	0.350 0.350	0.175 0.180	1.02 1.12	1.70 1.80	7.85 11.55
48 A E	6 130 9 740	0 256 0 407	7.68 12.21	0.190 0.305	0.400 0.400	0.240 0.245	1.47 1.57	2.30 2.52	9.98 15.73
54 A E	7 510 12 400	0 312 0 516	9.36 15.48	0.255 0.390	0.450 0.450	0.275 0.280	1.66 1.76	2.62 2.88	11.98 18.36
60 A E	8 900 15 100	0 370 0 628	11.10 18.84	0.275 0.470	0.500 0.500	0.325 0.330	1.96 2.12	3.07 3.42	14.41 23.27

Lead. — From the actual amount paid for lead on sixteen pipe-laying contracts having a total length of pipe laid of about twenty-two miles, varying in diameter from 12 inches to 60 inches, considerable variation in the amount of lead used per joint is shown. After careful examination, however, it seems that the extreme variations are due to well-explained causes, principally in carelessness, in putting more lead into the joint than is called for, and wasting in pouring the joints. At first sight it may seem absurd that a contractor would not be more than willing to fill a joint with yarn rather than lead. If, however, lead is cheap, the extra cost of the labor in yarning, added to the risk of being compelled to remove some if the joint is too full, may more than offset the cost of the extra lead. From experience on this work it appears that the rule given by Mr. Brackett of $2 \times$ diameter of pipe in inches = lbs. of lead per joint, will cover reasonable use for straight line work and will include the extra joints necessitated by valves, specials, short lengths, and solid joints. In order, however, to provide for carelessness and to include also in the straight line the lead used in the joints of blow-off and other connections, it might be well to add two per cent. to this figure. In connection with the cost of lead it may not be generally known that the dross is worth saving, as it can be sold to the lead manufacturers. In making up the cost in the above table the cost of lead is found by $\frac{2 \times \text{diameter of pipe in inches}}{12} \times \0.05 , assuming that as lead can usually be delivered for less than five cents per pound, the difference in cost will cover any deficiency in amount.

MISCELLANEOUS EXPENSES.

Tools. — From careful inventory of the tools used on a large contract before and after the work, and by inquiries among several extensive contractors, it was estimated that the tools remaining after the work was done had depreciated about one half in value. This, added to the cost of those used up and lost, was found to be about four per cent. of the average cost per linear foot of the contract work.

Insurance and Incidental Expense. — Based on bond costing one half per cent. of amount insured, accident policy costing three per cent. of labor pay-roll, and incidental expenses, one per

cent. of labor pay roll, this item is estimated at 3.2 per cent. of the total cost per linear foot.

Lumber, Yarn, etc. — Based on the accounts kept on a number of contracts where particular attention was given to these items, a fair allowance was estimated to be about 2.8 per cent. of the total cost of the contract. The allowance, then, for the three preceding items is taken in the tables as 10 per cent. of the cost of pipe laying.

Labor. — The cost of this item is in a general way based on the contract prices given in Table No. 2. It is, however, increased somewhat to conform with the current price of labor, which is estimated to be about ten per cent. higher than it was four or five years ago.

In a general way, the cost of labor at the present time may be taken as follows:

Foreman, \$100 per month.

Subforeman, \$3 per day.

Calkers and yarners, \$2.50 per day.

Laborers, 1st class, \$1.75 per day; 2d class, \$1.60 per day.

Double team and driver, \$0.45 per hour.

Single team and driver, \$0.30 per hour.

In addition to the cost per linear foot for laying the pipe, the following items should also be considered in making estimates:

Change in location of existing work, and extra work. — In the progress of the pipe laying some work has to be done usually for which no contract price is made.

For this work the contractor receives the actual cost plus fifteen per cent. It is made up in the estimate for payment under one of two headings: first, "change in location," which is local in its character, being confined to those portions of the location where structures already exist; second, miscellaneous work of any kind previously mentioned. This work extends over the entire location. In giving the following costs, that per foot for the first class is based on the actual length of line in which obstructions were found, and is estimated to be an average of \$0.09 per linear foot, with a variation from \$0.01 to \$0.30 per linear foot. These figures covered 38 miles out of a total of 62 miles of pipe laid, varying in size from 12 to 60 inches in diameter. The second item, "extra work," is taken from the cost on the above 62 miles, covering 36 pipe-laying contracts, and is estimated to

be an average of \$0.03 per linear foot and to vary from \$0.002 to \$0.11.

The following costs are given as about the amount usually received on contract bids: —

Rock above grade, \$3.50 per cubic yard.

Rock below grade, \$5.00 per cubic yard.

Setting air valves, \$3.50 each.

Chambers for valves 20 inches in diameter and larger, \$50.00 each.

Chambers for valves 16 inches in diameter and smaller, including those for air valves, \$40.00.

Acknowledgment. In the preparation of this article I am greatly indebted to the members of the Metropolitan Water Works force, and especially to Division Engineers W. E. Foss and J. L. Howard, for their kindness and courtesy.

DISCUSSION.

MR. H. G. HOLDEN. I should like to inquire if any provision was made for contraction on exposed places.

MR. SAVILLE. The pipe lines were not exposed to any extent. I think the only place where they are really exposed is the 36-inch pipe across Stony Brook. That was only about 34 or 35 feet long where exposed. The other pipes are covered in some way.

MR. GEORGE E. WINSLOW. I would like to ask with regard to these taper joints which were spoken of where they put down three pieces in a section. Was there any means provided for holding those against expansion? The reason I speak of it is, I should naturally think if there was any expansion the taper joint would give as quick or quicker than any other part of it and might work out of place.

MR. SAVILLE. In the Mystic River crossing, where the crossing was about one thousand feet long, there is a good deal of pipe to back up this taper joint. There was no provision to prevent the joints from pulling out.

MR. DEXTER BRACKETT. I will say that we have had, and I think we shall continue to have, leakage at these taper joints due to contraction of the pipes. With the change in the temperature of the water from 72 degrees in summer to 36 degrees in the

winter, we find that leaks develop in the fall or early winter on the joints in the pipes crossing the rivers, and these leaks generally occur at the taper joints.

MR. HOLDEN. How are these leaks repaired?

MR. BRACKETT. By re-calking, and in some cases by bolting the joints together, the work being done by a diver.

MR. ROBERT L. COCHRAN. I came here this afternoon to see if I could get a little information, and I think I have come to the right place. I am connected with a small plant in Nahant, and I have been a member of the Association for a good many years, but I believe this is the first time I have ever had the pleasure of standing up here before you. We are supplied in Nahant now by the Metropolitan system. We have about 11 000 feet of 10-inch pipe across the beach, which has been in for twelve or fourteen years, and last summer we concluded to increase our pipe sizes, and we were attached on to the Metropolitan system, and they advised us to have a standpipe. Mr. Coffin was the engineer who had charge of its construction. It is 95 feet high and 30 feet across. This winter we have had considerable trouble. In the summer time the 10-inch pipe will not supply us with water, that is, during four of five months, but Mr. Doane tells me that at the present time he could supply all we use with an inch pipe. I understand from Mr. Coffin that our standpipe holds 400 000 gallons of water. Well, I used to scratch my head these cold nights and wonder how I was going to keep the pipe from freezing. I was advised to shut off the supply from the town, and let the town use it, but the town would n't use a foot of water out of that pipe all day, and then what was I going to do in case of fire? I would have to turn on the supply again. I used to go and look at the gage, and a week ago last Sunday, the first day of February, I found the water had run down to about 75 feet in the standpipe, where we are supposed to have 85 feet. I hunted around all day to try to find out where the leak was, but could n't find any. I ought to have mentioned that they have a regulator which reduces our pressure to so many pounds on the beach, and they don't allow us to touch that. So I said the thing to do is to send for the doctor; and on Monday morning Mr. Killam came down, and he said, "The regulator is n't working." I said, "Well, you are the man to fix it." So he fixed it, and told us

to report in the morning. Well, I went and saw it in the morning and it registered 94 feet, and of course the pipe ought to overflow, but it did n't overflow, and I found out that the ice had extended up seven feet above the top of the tank. I sent for the "doctor" again, and we shut off the town and let them use the water out of the standpipe, and the ice still stood there. Now, I have come here to ask the cause of that; and if any other member has a standpipe that acts that way, I would like to have him tell me what I can do to prevent it.

THE PRESIDENT. There ought to be somebody here who can tell him what ought to be done.

MR. DEXTER BRACKETT. I have had no experience with standpipes similar to that described by Mr. Cochran, but I should suppose that it was due to the freezing of the water around the sides of the standpipe, and that when the water rose it carried the ice up with it. I think the gentleman at your right (Mr. Merrill) has had some experience with ice forming on the inside of a standpipe.

THE PRESIDENT. Mr. Merrill, will you tell us something about it?

MR. FRANK E. MERRILL. Mr. President, we did have a standpipe in Somerville at one time, but it has been removed, and at the present time we have nothing of the sort. Mr. Brackett refers to some experience that I have had, and I was trying to think what it was. I do remember now that a little ice formed in that standpipe one winter, but there was only a slight motion to it, because we kept the pipe pretty well filled most of the time. But the ice did at one time move sufficiently to pull a bolt which held the ladder on the inside of the standpipe in position out of its hole. It did n't require very much movement of the ice to do that, but the people in Somerville and some of the newspapers in Boston got hold of the story, and one would have thought from the description given of it that the standpipe was about ready to collapse. It was a very simple matter to fix it. All it was necessary to do was to draw the water down below the bolt hole, which was, as I remember, about two thirds of the distance from the bottom to the top of the pipe; and I merely put a plug into the bolt hole, knowing that the standpipe was to come down, or presuming it was to come down in a short time, and not thinking it worth

while to put the ladder back into position securely. The ladder was rarely used, anyway, it being the inside ladder. I think this is all the experience with ice in a standpipe that I have ever had. Since the introduction of the Metropolitan high service system into Somerville, pressure is supplied to us from Spot Pond Reservoir and the standpipe has been removed.

MR. BRACKETT. The point I wished to make with regard to the Somerville standpipe, and not particularly with regard to that more than any other, was that I think it is a fact that it was found that a very large amount of ice formed on the inside of the standpipe, even from the top to the bottom. I think this occurs in a great many standpipes. In cases where towns are supplied with ground water, that has a temperature of perhaps 45 or 50 degrees when it is pumped into the standpipe, less trouble from freezing occurs than in cases where the water is taken from a pond or stream with a temperature of from 36 to 38 degrees. I have serious doubts as to the advisability of pumping water into a standpipe at a temperature of 36 degrees unless the standpipe is housed in, and I should very much prefer that it should be housed in in any case. We have one standpipe which has been recently constructed with a tower around it, and observations taken there this winter show that no ice forms to do any injury. During the coldest weather a thin coating of ice has formed on the top surface, which soon breaks up, forming a slushy mixture but no solid ice.

To return again to the subject of pipe laying, we have with us to-day a gentleman who, I think, has had some recent experience with pipe laying under water in connection with the East Jersey Works, Mr. Cook, and perhaps he will be able to tell us something of interest.

MR. J. H. COOK. I really have n't very much to say about pipe laying under water. We have six 16-inch pipes under the Passaic River, which have been in about ten years or a little longer. They are very heavy wrought-iron pipes, and are connected by ordinary screw joints. They were hauled into a trench, and, as I say, they have been in about ten years, and they do not leak. We have tested them recently by means of a small meter placed on a by-pass, and have found them to be tight. What Mr. Brackett refers to is probably the 72-inch pipe which has been

put in by the Jersey City Water Supply Company to supply Jersey City. This pipe has recently been put across the Hackensack River, and they got it across very nicely. It was a pipe which was covered with concrete rings, and was placed in a trench, and everything seemed lovely, but a slight leak did develop. The leak has been repaired, but I really can't say very much about the details of the work or much about the repairing of the leak itself.

PROCEEDINGS.

MARCH MEETING.

HOTEL BRUNSWICK,
BOSTON, March 11, 1903.

Charles K. Walker, President, in the chair.

The following members and guests were present: —

MEMBERS.

S. A. Agnew, F. E. Appleton, Charles H. Baldwin, L. M. Bancroft, J. E. Beals, J. W. Blackmer, George Bowers, E. C. Brooks, E. W. Bush, J. W. Churchill, J. T. Cavanagh, George F. Chace, John C. Chase, F. C. Coffin, R. C. P. Coggeshall, M. F. Collins, H. A. Cook, J. W. Crawford, A. O. Doane, J. N. Ferguson, F. F. Forbes, A. D. Fuller, F. L. Fuller, D. H. Gilderson, F. W. Gow, R. A. Hale, J. O. Hall, E. A. W. Hammatt, J. C. Hammond, Jr., E. W. Kent, Willard Kent, C. F. Knowlton, James W. Locke, H. V. Macksey, F. A. McInnes, F. E. Merrill, F. L. Northrop, Dwight Porter, W. W. Robertson, A. T. Safford, C. W. Sherman, J. E. Smith, J. Waldo Smith, G. H. Snell, G. A. Stacy, W. F. Sullivan, C. N. Taylor, L. A. Taylor, R. J. Thomas, H. L. Thomas, D. N. Tower, W. H. Vaughn, C. K. Walker, F. B. Wilkins, G. E. Winslow. — 55.

ASSOCIATES.

Harold L. Bond & Co., by Harold L. Bond; Wm. V. Briggs; Builders Iron Foundry, by F. N. Connet; Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; M. J. Drummond, by Walter J. Drummond; Hersey Mfg. Co., by Albert S. Glover and Walter C. Hersey; Henry F. Jenks; Lamb & Ritchie, by Harry F. Peck; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Mueller Mfg. Co., by W. L. Dickel; National Meter Co., by C. H. Baldwin and J. G. Lufkin; Pittsburg Meter Co., by George F. Bard; Rensselaer Mfg. Co., by Fred S. Bates; A. P. Smith Mfg. Co., by D. F. O'Brien and M. G. Millikin; Sweet & Doyle, by H. L. DeWolfe. — 19.

GUESTS.

F. L. Weaver, M. J. Dowd, R. J. Crowley, Water Commissioners, and Mayor C. H. Howe, Lowell, Mass.; Lyman J. Webber, Brockton, Mass.; Theodore P. Moorehead, Foochow, China; John W. Lovett, Beverly, Mass.; Edward Atkinson, President Boston Manufacturers Mutual Fire Insurance Co.; C. L. Wilkins and K. S. Sweet, Massachusetts Institute Technology, Boston, Mass. — 10.

(Names counted twice. — 2.)

The first business was the election of new members. The Secretary presented the following names of applicants, all of whom had been duly approved by the Executive Committee: —

For Resident Members.

Kilburn S. Sweet, Boston, Instructor in Civil Engineering, Massachusetts Institute of Technology ; Guy W. Ricker, Salem, Mass., engaged in general civil engineering practice ; George A. King, Taunton, Mass., Superintendent Taunton Water Works ; Lyman J. Webber, Brockton, Mass., Engineer Water Works Pumping Station and Sewage Pumping Station.

For Non-Resident Member.

Charles L. Parmelee, New York, Consulting Engineer, N. Y. C. J. F. Co., and President General Construction Company.

By direction of the Association the Secretary cast one ballot in favor of the applicants, and they were declared elected.

President Walker then introduced Mayor Howe of Lowell, who spoke as follows: —

MAYOR HOWE. *Mr. President and Gentlemen*,— I suppose the high water in the Merrimac and the President of our water board are responsible for my being here to-day, and although I am very glad to be here, yet I think it is hardly fair to call upon me for any remarks, for I am not a speaker. If the water takers in the communities which are represented here could see the volume of water which is going through Lowell at the present time I think they would kick harder against their water rates than they do now.

I believe we in Lowell have the best water in the world. You might draw it from the faucet and bottle it up and sell it for any kind of fancy spring water that is being retailed in Boston to-day. It sparkles like champagne, and I drink it in preference to — well, to the spring water that my people buy. (Thomas did n't tell me to say this.) [Laughter.] The temperature of the water in the summer is about what it is to-day, and the water is always pure, wholesome, and has a good, clean taste. Now, gentlemen, I know that there are those here who are going to talk to you

about things that you are interested in, so I will not take any more of your time. [Applause.]

PRESIDENT WALKER. I am glad to see so many of you here to-day, gentlemen, and I congratulate you that spring has come and there will be no more frozen hydrants. [Laughter.] I read in the Boston *Advertiser* the other day that there was a great fire in Manchester and *twenty frozen hydrants*. Really, there were three hydrants frozen on top a little, but when the story got down here, the number had grown to twenty. I knew my friends would say to themselves, "What is the matter with Walker, twenty hydrants frozen around in one place?" but I thought they would n't believe it. [Laughter.] It is n't so, gentlemen; but we did have three hydrants that stuck on top. You ought to hear the papers and underwriters, like the gentleman here (Mr. Atkinson), go for me. But I slept all right, for I don't mind what people say about me because I have got accustomed to hearing them say 'most everything. Still I am glad that it is March, and there will be no more frozen hydrants. [Laughter.]

The President then called on Mr. George Bowers, City Engineer, Lowell, Mass., to read his paper entitled, "Underground Water; Suggestions on How to Obtain and Care for It." The subject was discussed by Mr. Edward Atkinson, A. O. Doane, and Charles N. Taylor.

The President announced that the Executive Committee had voted that the September convention be held in Montreal, and the June meeting in Waltham, and that Mr. Winslow, of Waltham, had been added to the committee, which consisted of Ex-Presidents Merrill and Holden, to arrange for the June meeting.

Mr. John C. Chase, Chief Engineer Water Works Company, Derry, N. H., then read a paper entitled, "A Little Talk about Water Rates."

Mr. Edward Atkinson, President Boston Manufacturers Mutual Fire Insurance Company, Boston, Mass., followed with a paper entitled, "Fuel; What we Don't Know about It." Messrs. Charles N. Taylor, Freeman C. Coffin, E. A. W. Hammatt, Vice-President Edwin C. Brooks, and Mr. Atkinson participated in the discussion which followed the reading of the paper.

Adjourned.

EXECUTIVE COMMITTEE.

RECORDS OF MEETING OF EXECUTIVE COMMITTEE OF NEW ENGLAND WATER WORKS ASSOCIATION, MARCH 11, 1903.

Present: President Charles K. Walker, Horace G. Holden, Edwin C. Brooks, J. C. Hammond, Jr., Charles W. Sherman, R. J. Thomas, L. M. Bancroft, Edmund W. Kent, George A. Stacy, Willard Kent, Frank E. Merrill.

Five applications are received from the following named parties: Charles L. Parmelee, of Orange, N. J.; Kilburn S. Sweet, of Boston, Mass.; Guy W. Ricker, of Salem, Mass.; George A. King, of Taunton, Mass.; Lyman J. Webber of Brockton, Mass.; who are all unanimously recommended for membership of the Association.

Consideration is given to place of holding next annual convention, and letters are read from Kenneth Allen, of Atlantic City, and J. O. A. LaForest, Chief Engineer, of Montreal. On motion of Mr. Thomas it is voted that the annual convention be held at Montreal, and that the present committee, consisting of Messrs. Holden and Merrill, be continued with full power to act.

The place of the June meeting is then considered, a letter from Mr. George E. Winslow is read setting forth the advantages of Norumbega Park and its surroundings, and it is voted that the June meeting be held at that place (Norumbega Park), with excursions to points of interest accessible therefrom, and a committee consisting of Messrs. Horace G. Holden, Frank E. Merrill, and George E. Winslow are appointed to make the necessary arrangements therefor.

Attest,

WILLARD KENT, *Secretary*.

NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XVII.

September, 1903.

No. 3.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

WATER WORKS STATISTICS FOR THE YEAR 1902, IN FORM ADOPTED BY THE NEW ENGLAND WATER WORKS ASSOCIATION.

COMPILED BY CHARLES W. SHERMAN, EDITOR, JOURNAL OF THE
NEW ENGLAND WATER WORKS ASSOCIATION.

The following tables of statistics contain more or less complete statistics for forty-four water works, which have used, more or less closely, the form adopted by the Association for summarizing statistics. Some of these works report under very few of the headings of the summary.

The Editor has made no attempt to compile statistics from water-works reports which do not include at least a partial summary.

The report of the Committee on Uniform Statistics, containing the form as endorsed for use in the 1901 reports, is printed on page 51 of vol. 15 of the JOURNAL (March, 1902). The page for Financial Statistics was changed by vote of the Association in September, 1902, as reported in the December, 1902, JOURNAL (vol. 16, p. 263). Blank forms for use in preparing summaries are printed by the Association, and will be furnished on request.

Previous compilations of statistics may be found in the JOURNAL, as follows:

<i>Statistics for</i>	<i>Reference to Journal.</i>
1886	Vol. I, No. 4, p. 29
1887	Vol. II, No. 4, p. 28
1888-1892	Vol. VII, p. 225
1893	Vol. IX, p. 127
1894	Vol. X, p. 131
1895-96	Vol. XII, p. 273
1897-99	Vol. XV, p. 65
1900	Vol. XV, p. 367
1901	Vol. XVI, p. 223

In the various tabulations, statistics are given for the following places and years:

<i>Place.</i>	<i>Year</i>
1. Albany, N. Y.	1900
2. Andover, Mass.	1900
3. Arlington, Mass.	1900
4. Atlantic City, N. J.	1898, 1900-02
5. Attleboro, Mass.	1894-1902
6. Bay City, Mich.	1886-87, 1893-96, 1900-02
7. Belmont, Mass.	1902
8. Billerica, Mass.	1899-1902
9. Boston, Mass.	1886-94, 1897, 1900
10. Brockton, Mass.	1893-1902
11. Burlington, Vt.	1886-1902
12. Cambridge, Mass.	1900-02
13. Chelsea, Mass.	1900-02
14. Cleveland, Ohio	1902
15. Concord, N. H.	1895, 1898, 1900-02
16. Dover, N. H.	1900
17. Erie, Pa.	1900
18. Essex Junc., Vt.	1900
19. Fall River, Mass.	1886-95, 1897-1902
20. Fitchburg, Mass.	1886-92, 1894-1902
21. Freeport, Me.	1901
22. Geneva, N. Y.	1900
23. Haverhill, Mass.	1900
24. Holyoke, Mass.	1886-92, 1897-98, 1900-02
25. Hull, England	1900
26. Ipswich, Mass.	1900
27. Keene, N. H.	1899-1900
28. Lawrence, Mass.	1902
29. Leicester, Mass.	1900
30. Leominster, Mass.	1900
31. Lewiston, Me.	1900
32. Lowell, Mass.	1886, 1897-1902
33. Lynn, Mass.	1888-98, 1900-02
34. Madison, Wis.	1900, 1902
35. Manchester, N. H.	1900
36. Marlborough, Mass.	1900
37. Maynard, Mass.	1901-02
38. Metropolitan Water Works, Mass.	1900-02
39. Middleboro, Mass.	1895-1902
40. Middletown, Conn.	1902
41. Minneapolis, Minn.	1900-02
42. Nantucket, Mass.	1900

43. Nashua, N. H.1900
44. New Bedford, Mass.1886-1902
45. New London, Conn.1886-1902
46. Newton, Mass.1888-1902
47. Norwich, Conn.1901
48. Oberlin, Ohio.1893-1902
49. Plymouth, Mass.1886-1902
50. Providence, R. I.1897-1902
51. Quincy, Mass.1893, 1900-01
52. Reading, Mass.1893, 1895-1902
53. Reading, Pa.1901-02
54. St. John, N. B.1902
55. Salem, Mass.1900
56. Sandusky, Ohio.1886
57. Schenectady, N. Y.1886, 1900-01
58. Somerville, Mass.1900-02
59. Springfield, Mass.1886-1902
60. Taunton, Mass.1886-1902
61. Toronto, Canada.1893
62. Trenton, N. J.1886-87
63. Troy, N. Y.1886, 1888-93, 1897-99
64. Waltham, Mass.1886-1902
65. Ware, Mass.1886, 1888-92, 1900-02
66. Watertown, Mass.1900
67. Wellesley, Mass.1888-93, 1898-1902
68. Westerly, R. I.1902
69. Whitman, Mass.1897-1902
70. Wilmington, Del.1900
71. Winchendon, Mass.1900-02
72. Woburn, Mass.1900-02
73. Woonsocket, R. I.1886-1900, 1902
74. Worcester, Mass.1900
75. Yonkers, N. Y.1893-96, 1900-02

1902. — TABLE 1. — GENERAL AND PUMPING STATISTICS.

Number.	Name of City or Town.	Date of Construction of Works.	By Whom Owned.	Source of Supply.	Mode of Supply.	2.—Description of Fuel Used.					
						1	a	b	c	d	e
						Builders of Pumping Machinery.	Kind.	Brand of Coal.	Av. Price per Gross Ton	Per Cent. of Ash.	Wood. Price per Cord.
1	Atlantic City, N. J.	{ 1882 1888 }	City.	{ Driven & Artesian Wells & Absecon Creek.	{ Pumping.	{ Worthington, Gordon-Max'll, d'Auria, Smith-Vaile.	Bituminous.	Standard. Eureka.	{ \$ 3 70 }	6	...
2	Attleboro, Mass.	1873	Town.	Well near Seven Mile River.	Pumping.	Deane, Barr.	Bituminous.	Georges Cr.	....	...	...
3	Bay City, Mich.	1872	City.	Saginaw Bay.	Pumping.	Holly.	Bituminous.	Slack.	1 65	23	\$1 33
4	Belmont, Mass.	1887	Town.	Metropolitan W.W.	.....	.....	.....	.....	....	...	...
5	Billerica, Mass.	1898	Town.	Driven Wells.	Pumping.	Barr.	Bituminous.	Georges Cr.	4 70	...	...
6	Brockton, Mass.	1880	City.	Salisbury Brook.	Pumping.	Worthington, Holly.	Bituminous.	Georges Cr.	5 15	9	...
7	Burlington, Vt.	1867	City.	Lake Champlain.	Pumping.	Worthington.	Bituminous, Mill Shavings.	Clearfield, Coaldale.	4 05 4 63	...	...
8	Cambridge, Mass.	1845	City.	{ Hobbs and Stony Brooks, Fresh Pond. }	{ Pumping.	{ Grosdon, Worthington, Blake. }	Bituminous.	Cumber- land.	4 30 8 50	...	...
9	Chelsea, Mass.	1867	City.	Metropolitan W.W.	.....	.....	.....	.....	....	...	...
10	Cleveland, Ohio.	1856	City.	Lake Erie.	Pumping.	{ Worthington, Knowles, Allis, Holly, Kilby. }	Bituminous.	Slack.	1 74 1 42	..	...
11	Concord, N. H.	1872	City.	Penacook Lake.	{ Gravity and Pumping. }	.....	.....	.....	....	...	...

12	Fall River, Mass.	1874	City.	N. Watuppa Lake.	Pumping.	Worthington, Davidson.	Bituminous.	Georges Cr.	....	10	...
13	Fitchburg, Mass.	1873	City.	Storage Reserv.	Gravity.	.....	.....	.....	....	...	...
14	Holyoke, Mass.	1873	City.	Lakes, Streams & Manhan River.	Gravity.	.....	.....	.....	....	...	...
15	Lawrence, Mass.	1874	City.	Merrimac River (filtered).	Pumping.	Barron Morris, L	Bituminous.	Georges Cr. & Pocatash.	4 88	8	...
16	Lowell, Mass.	{ 1870 1893	City.	555 Driven Wells.	Pumping.	{ Morris, Worthington, Deane, Knowles.	Bituminous.	....	5 48	...	...
17	Lynn, Mass.	1871	City.	Ponds and River.	Pumping.	Leavitt, Loretz.	Bituminous.	Georges Cr.	5 00	10	...
18	Madison, Wis.	1881	City.	Artesian Wells.	Pumping.	Allis, Knowles.	Anthracite.	Pea.	5 37	...	...
19	Maynard, Mass.	1889	Town.	White Pond.	Pumping.	Blake.	Bituminous.	Georges Cr.	4 65	20	...
20	Metropolitan Water Works, Mass.	{ 1848 1872 1895	State of Massa- chusetts.	{ Lake Cochituate, Sudbury River, Nashua River.	Pumping.	{ Chestnut Holly, Quintard, Iron Works, Allis.	{ Hill High Bituminous.	{ Service Georges Creek, Loyal Hanna. Screen'gs.	{ Station. 4 85	11	...
						Chestnut	Hill Low	Service Georges Creek, Loyal Hanna.	Station. 4 95		
						Holly.	Bituminous.	.....	.....
						Spot	Pond	Station.	.....	
						{ Blake, Holly.	{ Bituminous.	{ Loyal Hanna, Georges Creek, Bu'kwit	{ 5 26	11	...
						Anthracite.	Anthracite.	.....	.....

H=High service.

L=Low service.

1902. — TABLE 1. — *Continued.* — GENERAL AND PUMPING STATISTICS.

Number.	Name of City or Town.	Date of Construction of Works.	By Whom Owned.	Source of Supply.	Mode of Supply.	1		2.—Description of Fuel Used.				
						Builders of Pumping Machinery.	a	b	c	d	e	
21	Middleboro, Mass.	1885	Fire Dist.	{ Well near Ne-masket River.	Pumping.	Deane.	Bituminous.	Poc'h'tas, Cumber-land.	\$4 50 5 90	...	...
22	Middletown, Conn.	{ 1866 1897	City.	Impounding Res.	Gravity.	. . . . .	. . . . .	. . . . .	. . . . .	...	...
23	Minneapolis, Minn.	1868	City.	Mississippi River.	Pumping.	Hardenburg, Waters, Pray, Worthington, Holly.	Sawdust, Edgings, etc. (also water power).	. . . . .	. . . . .	...	...
24	New Bedford, Mass.	{ 1866 1895	City.	Quittacas Ponds.	Pumping.	Dickson.	Bituminous.	Poc'h'tas.	4 95	7	\$4 00	
25	New London, Conn.	1872	City.	Lake Konomoc.	{ Gravity and Pumping.	. . . . .	. . . . .	. . . . .	. . . . .	...	...
26	Newton, Mass.	1876	City.	{ Collecting gallery } near Charles Riv.	Pumping.	Blake, Worthington.	{ Bituminous. Anthracite Screenings.	{ Georges Creek, Pa.	5 09	9	6 00	
27	Oberlin, Ohio.	1887	Village.	{ East branch Vermilion River.	Pumping.	Deane.	Bituminous.	Poc'h'tas.	4 00	...	...
28	Plymouth, Mass.	1855	Town.	{ Great and Little South Ponds, Lout Pond.	{ Gravity (L) and Pumping (H).	{ Worthington.	Bituminous.	Various.	6 00	...	...
29	Providence, R.I.	1870	City.	Pawtuxet River.	Pumping.	Worthington, Corliss, Holly.	Bituminous. Bituminous. Anthracite.	Georges Cr. Georges Cr. Egg (Pa.).	5 21 4 66 5 35	10 14 19	4 50 4 50 4 00	

30	Reading, Mass.	890	Town.	Filter Gallery.	Pumping.	Blake.	Bituminous. Coke.	Georges Cr.	5 90	...	...
31	Reading, Pa.	1819	City.	Creeks & Springs.	Gravity, 60% Pumping, 40%.	Worthington.	Anthr., Bit. & Riv. Coal.	....	3 11	14	3 50
32	St. John, N. B.	{ 1851 1859 }	{ City. }	{ East Side, Little River, West Side, Spruce Lake. }	Gravity (L). Pumping (H).	. . . . .	Water Power.	....	....	....	....
33	Somerville, Mass.	1868	City.	Metropolitan W.W.	. . . . .	. . . . .	. . . . .	....	....	....	....
34	Springfield, Mass.	{ 1864 1873 1890 }	{ City. }	Impounding Res's.	Gravity.	. . . . .	. . . . .	....	....	....	....
35	Taunton, Mass.	1876	City.	{ Elder's and Assawompsett Ponds. }	Pumping.	Holly, Allis.	Bituminous.	Cumber- land.	4 20-5 00 6 00-6 50	12 10	....
36	Waltham, Mass.	1872	City.	Filter Basin near Charles River.	Pumping.	Barr, Worth- ington.	Bituminous.	Georges Cr. Welsh.	5 64	12	....
37	Ware, Mass.	1886	Town.	Wells.	Pumping.	Dean, Warren.	Bituminous.	....	8 43	...	5 00
38	Wellesley, Mass.	1884	Town.	Wells.	Pumping.	Blake.	{ Bituminous, Anthracite. }	Puritan. Screen gs.	4 95 1 50	10	3 50
39	Westerly, R. I.	1886	Town.	Driven Wells.	Pumping.	Worthington.	Bituminous.	Georges Cr.	....	....	....
40	Whitman, Mass.	1883	Town.	Well.	Pumping.	Blake, Worthington.	. . . . .	....	....	....	....
41	Winchendon, Mass.	1896	Town.	Well.	Pumping.	Blake.	Bituminous.	Pardee.	5 04	7	....
42	Woburn, Mass.	1872	City.	Filter Gallery near Horn Pond.	Pumping.	Worthington, Blake.	Bituminous { Elk Gard'n Georges Creek, etc. }	....	5 12	9	....
43	Woonsocket, R. I.	1884	City.	Crook Fall Brook.	Pumping.	Worthington, Deane.	Bituminous { Poc'h'tas, New River, Georges Cr. }	....	5 55	8	3 00
44	Yonkers, N. Y.	1874	City.	{ Sprain and Grassy Sprain Brooks, and Tube Wells. }	Pumping.	{ Wright, Worthington, Camden. }	Bituminous.	Georges Cr.	3 85 10 50	...	10 00

n=High service.

L=Low service.

1902.—TABLE 1, *Concluded*.—PUMPING STATISTICS.

Number.	3		4	4a	5	6	7	8	9	10	11	12
	Coal Consumed for the Year. (Lbs.)		Lbs. of Wood + 3 = Equivalent Coal.	Amount of Other Fuel Used.	Total Equivalent Coal Consumed for the Year. (Lbs.) (3) + (4).	Total Pumpage for the Year in Gallons.	Average Static Head against which Pumps Work. (Feet.)	Average Dynamic Head against which Pumps Work. (Feet.)	Number of Gallons Pumped per Lb. of Equivalent Coal.	Duty in Foot-pounds per 100 Pounds of Coal. No Deductions.	Cost per Million Gallons pumped into Reservoir, figured on Pumping Station Expenses.	Cost per Million Gallons raised 1 Foot high, figured on Pumping Station Expenses.
1	{ 3 058 497	{ 1 188 461	3 000	...	3 061 497	1 198 128 803 ¹	95	110	391	35 897 900	\$ 9 29	\$0 085
2	{ 528 275	...	500	...	1 188 961	167 400 508 ²	120	{ 120 188 } 225	141	14 091 300 ⁴	33 21	0 278
3	4 728 800	...	3 667	...	4 732 467	158 024 210	...	113	310	58 200 000	...	...
4	231 035	...	...	...	...	21 946 359 ³	275	317	95	21 301 161	7 34	0 065
5	482 071	...	0	...	482 071	497 300 329 ³	38	43	1 032	25 108 771	73 29	0 23
6	4 097 200	...	500	...	4 097 700	293 386 475	289	316	1	36 994 933	3 56	0 082
7	...	...	...	...	...	2 930 553 545 ³	158	194	715	115 974 363	29 55	0 10
8	91 984 190	...	...	...	...	25 537 131 076 ³	173	205	278	47 489 432	5 32	0 028
9	295 884	...	...	...	...	148 876 167	...	186	500	...	...	0 026
10	4 882 075	...	...	...	...	1 593 248 921	...	...	326	...	11 94	...
11	...	...	...	...	...	...	...	...	...	...	...	...
12	391 533 ^H	...	...	...	391 533 ^H	127 844 980 ^H	295 ^H	323 ^H	327 ^H	88 074 104 ^H	...	{ 0 076 ^H
13	{ 2 271 267 ^L	...	...	...	2 271 267 ^L	1 122 435 290 ^L	152 ^L	185 ^L	494 ^L	76 248 429 ^L	12 12	{ 0 058 ^L
14	...	...	...	...	...	...	...	...	...	...	...	...
15	...	...	...	...	...	...	...	...	...	...	...	...
16	{ 9 012 775	{ 3 749 273 ⁵	2 400	...	9 015 175	2 090 924 110	156	162	232	74 646 252 ⁵	18 84	0 116
17	2 686 600	...	...	...	2 686 600	1 709 855 000	147	149	636	87 757 210	6 43	0 043
18	1 635 100	...	...	...	...	458 815 100	201	228	...	...	...	...
19	299 778	...	...	...	299 778	54 884 545 ³	190	212	183	31 240 547	30 29	0 143
20	Chestnut	...	Hill	High	Service	Station.	...	...	...	...	...	...
a	380 417	...	...	...	...	273 900 000	...	120	720	75 130 000	9 30	0 078
c	443 134	...	...	...	...	503 390 000	...	124	1 136	120 700 000	4 66	0 038
e	8 078 166	...	...	...	...	10 118 610 000	...	128	1 253	136 010 000	3 89	0 030

1902.—TABLE 2.—FINANCIAL STATISTICS.

Number.	Name of City or Town.	RECEIPTS.						Municipal Departments.		
		Balance Brought Forward.		Water Rates.			C	D	E	For Fountains.
		a	b	A	B	Fixture Rates.				
		From Ordinary Receipts.	From Extraordinary Receipts.		Meter Rates.		Total from Consumers.	For Hydrants.		
1	Atlantic City, N. J.	\$ 9 696 93	\$ 38 602 85	. . . . .	. . . . .	. . . . .	\$102 906 98	. . . . .	. . . . .	. . . . .
2	Attleboro, Mass. . . . .	. . . . .	1 594 81	. . . . .	. . . . .	. . . . .	25 263 08	. . . . .	. . . . .	. . . . .
3	Bay City, Mich.	13 878 67	. . . . .	\$9 440 23	\$15 103 83	. . . . .	24 544 06	. . . . .	. . . . .	. . . . .
4	Belmont, Mass.	3 617 09	2 783 17	. . . . .	12 293 02	. . . . .	12 293 02	. . . . .	. . . . .	. . . . .
5	Billerica, Mass. . . . .	. . . . .	45 41	1 357 61	1 427 32	. . . . .	2 784 93	\$ 2 300 00	. . . . .	. . . . .
6	Brockton, Mass. . . . .	. . . . .	5 395 07	6 042 72	84 390 41	. . . . .	90 433 13	3 000 00	. . . . .	. . . . .
7	Burlington, Vt. . . . .	. . . . .	. . . . .	8 246 09	34 571 38	. . . . .	42 817 47	3 480 00	\$ 244 50 ²	. . . . .
8	Cambridge, Mass.	1 583 30	. . . . .	194 466 70	132 000 00	. . . . .	326 466 70	. . . . .	. . . . .	. . . . .
9	Chelsea, Mass. . . . .	. . . . .	. . . . .	77 000 30	23 629 86	. . . . .	100 630 16	2 242 80	13 50	. . . . .
10	Cleveland, Ohio	0	169 829 09	430 361 30	433 778 81	. . . . .	864 140 11	. . . . .	. . . . .	. . . . .
11	Concord, N. H. . . . .	. . . . .	. . . . .	29 314 64	33 514 50	. . . . .	62 829 14	. . . . .	. . . . .	. . . . .
12	Fall River, Mass.	59 064 78	. . . . .	3 559 59	171 677 36	. . . . .	175 236 95	. . . . .	. . . . .	. . . . .
13	Fitchburg, Mass. . . . .	. . . . .	. . . . .	23 210 39	42 585 31	. . . . .	65 795 70	. . . . .	. . . . .	. . . . .
14	Holyoke, Mass.	3 608 76	. . . . .	77 888 25	23 873 35	. . . . .	101 761 60	. . . . .	. . . . .	. . . . .
16	Lowell, Mass. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
17	Lynn, Mass. . . . .	. . . . .	. . . . .	116 162 92	86 865 14	. . . . .	204 028 06	. . . . .	. . . . .	. . . . .
18	Madison, Wis.	6 493 59	. . . . .	. . . . .	. . . . .	. . . . .	29 250 46	. . . . .	. . . . .	. . . . .
19	Maynard, Mass.	3 110 33	. . . . .	4 560 42	1 807 33	. . . . .	6 367 75	2 000 00	6 60	. . . . .

21	Middleboro, Mass.	3 992 21	. . . .	3 635 84	6 922 41	10 558 25	. . . .
22	Middletown, Conn.	39 376 23	839 86	25 592 19	5 274 79	30 866 98	5 195 00
23	Minneapolis, Minn.	218 796 19	. . . .	. . . .	. . . .	232 082 84	. . . .
24	New Bedford, Mass.	12 561 30	11 368 74	73 990 25	38 116 19	112 106 44	. . . .
25	New London, Conn.	. . . .	75 645 34	. . . .	. . . .	51 668 02	11 840 00 ¹
26	Newton, Mass.	. . . .	. . . .	3 618 00	103 667 00	107 285 00	840 00
27	Oberlin, O.	1 162 26	. . . .	1 300 00	5 456 75	6 756 75	. . . .
28	Plymouth, Mass.	. . . .	. . . .	. . . .	. . . .	24 750 74	. . . .
29	Providence, R. I.	. . . .	. . . .	. . . .	. . . .	605 307 35	. . . .
30	Reading, Mass.	358 98	225 10	. . . .	9 388 96	9 388 96	4 830 00
31	Reading, Pa.	98 272 89	. . . .	131 860 53	43 257 00	175 117 53	. . . .
33	Somerville, Mass.	. . . .	. . . .	163 231 98	50 733 53	213 965 51	. . . .
34	Springfield, Mass.	13 063 29	. . . .	148 379 25	75 523 83	223 903 08	19 440 00 ¹
35	Taunton, Mass.	. . . .	8 400 46	. . . .	. . . .	61 621 73	2 033 58
36	Waltham, Mass.	7 432 80	4 013 53	60 624 80	9 589 73	70 214 53	. . . .
37	Ware, Mass.	2 597 77	798 81	. . . .	8 400 65	8 400 65	1 000 00
38	Wellesley, Mass.	5 200 65	. . . .	{ 725 00 1 995 09	14 151 22	14 151 22	4 000 00
39	Westerly, R. I.	. . . .	. . . .	. . . .	19 176 97	21 897 06	2 482 12
40	Whitman, Mass.	. . . .	1 986 37	2 243 42	4 116 80	6 360 22	2 740 00
41	Winchendon, Mass.	2 847 95	. . . .	33 43	4 788 37	4 821 80	305 00
42	Woburn, Mass.	. . . .	16 45	34 639 90	5 929 31	40 569 21	275 00
43	Woonsocket, R. I.	. . . .	. . . .	2 325 28	56 215 27	58 540 55	16 315 00
44	Yonkers, N. Y.	3 717 83	. . . .	. . . .	. . . .	122 319 18	25 740 00

¹ Book-keeping account only; no cash received.² Paid at meter rates, and included in receipts—meter rates.

21	.	.	.	.	.	.	1 500 00	.	.	.	.	785 91	16 836 37
22	.	.	.	85 00	.	.	5 465 00	.	.	.	.	3 888 11	40 216 09
23	.	.	.	.	.	.	.	.	.	.	253 125 00	344 705 16	795 584 19
24	.	.	.	.	.	.	12 000 00	65 880 00	.	.	7 500 00	.	221 416 48
25	4 000 00 ²	.	.	400 00 ²	.	.	.	.	.	.	.	.	143 703 36
26	3 000 00	.	.	2 660 00	.	.	6 500 00	.	.	.	30 425 41	14 640 28	158 850 69
27	.	.	.	.	.	.	.	4 699 84	.	.	.	756 91	13 376 36
28	.	.	.	.	.	.	0	.	.	.	.	{ 1 313 54 ¹	26 939 16
29	.	.	.	.	.	.	.	.	.	.	.	{ 874 88	.
30	300 00	.	.	.	.	.	5 430 00	2 500 00	.	.	2 000 00	10 437 85	30 340 89
31	.	.	.	.	.	.	.	.	.	.	.	11 695 12	285 085 54
33	.	.	.	.	.	.	.	.	.	.	.	6 046 39	220 011 90
34	11 675 12 ²	.	.	12 445 15 ²	.	.	45 376 37 ²	.	.	.	.	{ 21 513 40	} 305 247 62
35	0	.	.	530 17	.	.	2 563 75	.	.	.	.	736 00 ²	
36	.	.	.	.	.	.	.	.	.	.	.	665 48	
37	.	.	.	211 84	.	.	.	.	.	.	5 000 00	6 470 04	79 055 98
38	→	.	.	118 68	.	.	1 748 58	2 700 00	.	.	.	4 038 70	91 359 56
39	.	.	.	.	.	.	4 118 68	.	.	.	2 000 00	332 37	16 578 18
40	.	.	.	.	.	.	.	.	.	.	75 506 37	1 267 15	26 737 70
41	143 16	.	.	.	.	.	.	.	.	.	.	{ 4 368 12	.
42	250 00	.	.	792 00	.	.	4 648 16	2 000 00	.	.	.	3 462 91	.
43	1 483 95	.	.	1 800 49	.	.	1 317 00	637 44	.	.	2 000 00	694 74	13 781 33
44	.	.	.	.	.	.	36 000 00	15 300	.	.	.	38 73	14 356 64
												1 212 61	45 752 71
												2 738 88	112 579 43
											111 710 00	4 100 30	.

¹ Ordinary balance (overdrawn).² Book-keeping account only; no cash received.³ Paid at meter rates, and included in receipts — meter rates.

1902.—TABLE 2, Continued.—FINANCIAL STATISTICS.

Number.	MAINTENANCE EXPENDITURES.			DD Interest on Bonds.	EE Payment of Bonds.	FF Sinking Fund.	CONSTRUCTION EXPENDITURES.				
	AA Operation.	BB Special.	CC Total Maintenance.				GG Extension of Mains.	HH Extension of Services.	II Extension of Meters.	JJ Special.	KK Total Construc- tion.
1	. . .	. . .	\$44 468 95	\$54 191	....	\$19 700	\$24 995 79	\$8 045 16	\$6 059 80	\$46 174 61	\$85 275 36
2	. . .	. . .	10 941 81	14 120	....	5 200	. . .	. . .	. . .	. . .	32 038 13
3	\$13 924 65	. . .	13 924 65	20 390	\$20 000	. . .	11 044 80	. . .	583 90	. . .	11 628 70
4	1 480 23	\$4 683 09	6 163 32	1 690	2 250	520	812 15	789 46	364 95	160 69	2 127 25
5	2 402 25	. . .	2 402 25	3 600	....	. . .	. . .	390 90	. . .	51 21	442 11
6	19 458 49	. . .	19 458 49	33 762 50	....	. . .	28 077 59	2 366 40	6 992 41	62 919 35	100 355 75
7	30 891 35	. . .	. . .	9 920	....	4 272 01	897 80	276 37	. . .	. . .	1 174 17
8	59 943 64	11 658 32	. . .	129 579	. . .	120 828 75	13 970 34	2 355 23	3 028 80	5 947 60	. . .
9	15 599 19	32 178 83	47 778 02	12 000	....	5 410	1 391 15	937 65	42 34	977 85	3 348 99
10	242 506 34	. . .	242 506 34	132 370	....	. . .	256 617 34	0	155 019 60	585 276 83	996 913 77
11	. . .	. . .	9 687 83	25 450	....	. . .	4 812	2 197 89	987 08	5 910 36	23 907 33
12	51 777 49	. . .	. . .	93 975	....	. . .	. . .	. . .	. . .	. . .	20 000 00
13	. . .	. . .	. . .	. . .	....	. . .	. . .	. . .	. . .	. . .	. . .
14	28 095 67	1 547 72	29 643 39	12 000	....	13 000	1 091 06	. . .	602 25	16 465 42	18 158 73
16	. . .	. . .	97 011 14	49 409	31 600	. . .	. . .	. . .	. . .	. . .	25 501 72
17	73 897 23	. . .	73 897 23	79 248 75	....	\$3 027 59	3 804 77	7 350 23	. . .	179 184 68	190 339 68
18	. . .	. . .	13 551 69	. . .	....	. . .	. . .	. . .	. . .	. . .	24 960 32
19	5 790 09	. . .	. . .	5 000	....	. . .	. . .	. . .	. . .	. . .	. . .
21	5 075 72	. . .	5 075 72	2 180	....	5 000	561 76	417 11	157 60	. . .	1 136 47

22	7 382 71	830 84	8 213 55	11 407 50	.....	12 289 94	7 287 76	818 25	136 09	63	8 305 10
23	.....	.....	97 541 23	.....	.....	.....	23 144 58	.....	.....	127 755 19	149 999 77
24	39 387 44	.....	39 387 44	75 880	30 000	28 000	20 276 79	4 256 33	2 644 97	386 49	27 564 58
25	7 345 27	.....	.....	18 415	.....	.....	17 677 78	2 025 61	230 93	86 139 34	106 073 66
26	17 676 81	.....	17 676 81	98 987 50	.....	.....	8 666	10 197	5 218	12 587 69	36 668 69
27	2 908 77	.....	2 908 77	1 540	2 000	1 159 84	2 803 61	875 44	843 84	46	4 569 89
28	10 556 08	.....	.....	4 594 50	7 640	.....	2 922 16	342 60	.....	883 32	4 148 58
29	.....	.....	134 104 04	.....	.....	.....	.....	.....	.....	.....	.....
30	7 465 68	.....	7 465 68	8 782 50	.....	.....	1 765 67	1 359 13	422 73	10 495 77	14 043 30
31	53 006 40	1 575 24	54 581 64	15 508	.....	7 500	34 682 70	0	2 733 37	113 321 68	150 737 75
33	16 704 48	19 944 60	36 649 08	6 790	29 000	.....	11 710 15	3 667 71	762 06	.....	16 139 92
34	23 151 26	$\left\{ \begin{array}{l} 551 18 \\ 198 43 \\ 16 664 28 \end{array} \right.$	.....	85 500	.....	31 833 58	3 060 71	.....	.....	88 365 43	91 426 14
35	27 432 76	.....	27 432 76	33 168	.....	4 398 72	4 879 22	5 064 54	1 841 89	309 35	12 095 00
36	32 064 31	.....	32 064 31	17 237 50	.....	26 037 43	.....	.....	.....	.....	7 889 50
37	7 070 99	.....	7 070 99	1 359	2 700	.....	.....	.....	.....	.....	3 086 21
38	6 395 49	.....	6 395 49	11 300	.....	.....	1 408 63	1 167 37	225 00	.....	2 861 00
39	.....	.....	10 511 40	10 561 40	.....	.....	.....	.....	.....	.....	83 072 41
40	.....	.....	4 959 07	4 000	.....	2 000	.....	.....	.....	.....	801 84
41	2 666 94	.....	2 666 94	3 720	2 000	.....	2 415 84	943 34	442 08	.....	3 801 26
42	13 251 55	.....	.....	3 676	.....	25 930 03	2 230 63	909 00	.....	.....	3 139 63
43	13 288 71	.....	.....	28 280	.....	.....	← .....	17 846 72	→ .....	.....	17 846 72
44	56 354 39	.....	.....	80 522 92	.....	19 000	.....	.....	.....	.....	101 895 95

1 Metropolitan Water Assessment.

1902.—TABLE 2, *Concluded*.—FINANCIAL STATISTICS.

Number.	LL Unclassified Expenses.	MM BALANCE.		N Total.	Disposition of Balance. (2)	O Net Cost of Works to Date.	P Bonded Debt at Date.	Q Value of Sinking Fund.	R Average Rate of Interest, Per cent.
		aa Ordinary.	bb Extraordinary.						
1	\$ 73 273 16		\$ 7 307 65	\$ 284 216 12	. . .	\$1 260 567 74	\$1 175 500	\$ 147 807 76	4 75
2	. . . .	\$ 1 27	3 565 84	. . . .	. . .	421 955 43	327 000	50 554 42	. . .
3	. . . .	13 459 85	. . . .	79 403 20	Deposited	618 832 85	342 000	. . . .	5 85
4	. . . .	5 792 84	655 92	19 199 33	Forward	. . . .	38 250	3 160 26	4
5	. . . .	. . . .	. . . .	6 444 36	. . .	92 147 98	90 000	5 062 75	5
6	. . . .	41 917 74	19 168 02	. . . .	. . .	1 043 871 31	915 000	420 899 61	3 75
7	. . . .	. . . .	. . . .	46 257 53	. . .	475 635 40	248 000	44 000 00	4
8	. . . .	. . . .	. . . .	347 311 68	. . .	5 724 301 60	3 350 600	. . . .	3½ to 4
9	. . . .	40 494 30	. . . .	109 031 31	C. T.	491 552 68	300 000	71 787 00	4
10	. . . .	394 041 21	. . . .	1 765 831 32	Forward	9 999 234 22	3 287 000	0	4
11	. . . .	4 485 69	. . . .	63 530 85	. . .	890 565 12	640 000	. . . .	3 94
12	. . . .	93 989 03	. . . .	259 741 52	Forward	1 988 306 45	2 060 000	700 691 67	4 6
13	37 333 16	31 932 06	. . . .	69 265 22	C. T.	408 713 39	537 000	128 286 61	. . .
14	26 849 98	13 985 57	. . . .	113 637 67	. . .	1 295 308 26	300 000	57 235 71	. . .
16	. . . .	. . . .	. . . .	. . . .	. . .	. . . .	1 205 500	. . . .	4
17	. . . .	. . . .	208 945 27	635 458 52	Forward	2 677 710 83	2 175 300	642 797 44	4
18	1 872 34	6 651 89	. . . .	47 036 24	. . .	380 031 32	20 000	. . . .	3 9
19	. . . .	1 369 96	. . . .	12 160 05	. . .	154 000 00	125 000	17 690 69	4
21	. . . .	3 444 18	. . . .	16 836 37	Forward	118 605 66	51 500	8 886 12	4

22	. . . .	. . . .	40 216 09	S. F.	583 861 54	289 000	44 958 26	3 65 & 4
23	39 296 03	508 747 16	. . . .	Forward	4 707 957 49	1 830 000	. . . .	3 85
24	. . . .	13 084 46	7 500 00	Forward	3 186 761 14	1 698 000	216 583 90	4 39
25	. . . .	. . . .	11 869 43	. . . .	894 464 12	501 000	. . . .	3 68
26	. . . .	5 517 69	. . . .	. . . .	2 120 937 60	2 135 000	984 825 00	4 6
27	106 79	1 092 02	. . . .	Extens.	92 814 52	43 000	1 159 84	3½
28	. . . .	. . . .	26 939 16	. . . .	328 378 21	111 680	. . . .	4 12
29	. . . .	. . . .	. . . .	. . . .	6 496 966 27	6 009 000	1 259 570 60	3 75
30	. . . .	49 41	. . . .	. . . .	286 754 96	223 000	. . . .	4
31	925 46	55 832 69	30 340 89	Forward	2 078 537 06	400 000	13 690 00	4
33	{ 62 397 89 ¹ 225 70	68 809 31	220 011 90	C. T.	801 830 14	146 000	. . . .	4
34	45 285 37 ²	10 637 38	305 247 62	. . . .	2 232 033 92	1 450 000	560 671 00	5 83
35	. . . .	. . . .	1 961 50	S. F.	1 294 567 50	829 200	238 012 72	4
36	. . . .	3 465 59	91 339 56	. . . .	620 334 77	438 000	155 499 68	3 88
37	. . . .	1 649 38	712 60	. . . .	137 843 69	36 000	. . . .	3 63
38	882 10	4 768 82	530 29	Forward	331 471 13	280 000	103 311 13	4
39	. . . .	. . . .	. . . .	. . . .	359 379 96	. . . .	43 137 09	. . . .
40	. . . .	816 62	13 781 33	Construction	132 416 71	100 000	41 540 34	4
41	. . . .	2 168 44	14 356 64	. . . .	121 476 67	91 000	. . . .	4
42	. . . .	. . . .	-244 50	S. F.	600 595 95	72 000	. . . .	4
43	. . . .	53 090 24	73 76	. . . .	. . . .	732 000	104 407 43	3 8
44	. . . .	. . . .	9 814 05	. . . .	1 676 984 51	1 585 000	391 572 31	5 33
	. . . .	. . . .	. . . .	. . . .	2 252 976 98	752 000	31 823 91	4 & 6

¹ Metropolitan Water Assessment.
² Book-keeping account only; no cash paid.

³ Forward=carried forward to next year's account.
 { C. T.=to City Treasury.
 Extens.=to be used for extensions.

Construction=transferred to Construction Account.
 S. F.=to Sinking Fund.

1902.—TABLE 3.—STATISTICS OF CONSUMPTION OF WATER.

Number.	Name of City or Town.	Estimated Population.			4	5	6	Average Consumption. (Gallons per Day.)				11	12			
		Total at Date.		On Line of Pipe.				Supplied at Date.	Quantity Used through Meters. (Gallons.)	Percentage of Consumption Metered.	Total.			To Each Inhabitant.	To Each Consumer.	To Each Tap.
1	Atlantic City, N. J.	36 000	35 500	{ 35 500 ¹ 150 000 ²	{ 1 364 519 311 158 024 210 1 069 661 847	. . . . .	. . . . .	. . . . .	{ 3 738 000 5 274 000 ²	104	{ 59 825	{ \$32 59 35 ³	{ \$72 30 30
2	Attleboro, Mass.	12 500	11 500	17 000	158 024 210	. . . . .	. . . . .	. . . . .	34	37	1264	13 02	32 08
3	Bay City, Mich.	28 000	20 500	17 000	1 069 661 847	. . . . .	. . . . .	. . . . .	18	172	30	273 45	107 01
4	Belmont, Mass.	4 300	4 100	4 000	21 946 359	. . . . .	. . . . .	. . . . .	All	45	240	129 15	25 24
5	Billerica, Mass.	2 800	1 800	1 330	497 300 329	. . . . .	. . . . .	. . . . .	54	36	551	50 88	63 66
6	Brockton, Mass.	44 500	41 000	37 800	293 386 475	. . . . .	. . . . .	. . . . .	32	85	1231	9 50	14 68
7	Burlington, Vt.	19 200	18 700	18 600	2 930 553 545	. . . . .	. . . . .	. . . . .	27	173	105	41	105
8	Cambridge, Mass.	94 152	94 152	94 152	25 537 131 076	. . . . .	. . . . .	. . . . .	26	104	1300	50 47	76 14
9	Chelsea, Mass.	34 000	34 000	34 000	1 593 248 921	. . . . .	. . . . .	. . . . .	45	53	537	43 27	90 00
10	Cleveland, Ohio.	424 000	410 000	405 000	1 058 500 000 ¹	. . . . .	. . . . .	. . . . .	25	63	360	18 00	43 00
11	Fall River, Mass.	108 728	107 653	107 653	1 751 410 900 ¹	. . . . .	. . . . .	. . . . .	30	67	402	50 88	63 66
12	Fitchburg, Mass.	32 000	27 500	27 500	1 250 280 270	. . . . .	. . . . .	. . . . .	20	123	54	61	280
13	Folyoke, Mass.	47 043 ⁵	46 543	46 043	1 709 855 000	. . . . .	. . . . .	. . . . .	42	61	280	18 00	43 00
14	Lawrence, Mass.	68 500	65 000	65 000	458 815 100	. . . . .	. . . . .	. . . . .	15	100	657	16 94	49 96
15	Lowell, Mass.	100 000	74 000	74 000	54 884 545	. . . . .	. . . . .	. . . . .	27	78	390	166 10	16 16
16	Lynn, Mass.	75 000	74 000	74 000	39 152 660 000	. . . . .	. . . . .	. . . . .	25	54	264	59 60	91 16
17	Madison, Wis.	20 000	3 000	2 800	1 709 855 000	. . . . .	. . . . .	. . . . .	30	63	360	140 14	305 16
18	Maynard, Mass.	3 500	3 000	2 800	458 815 100	. . . . .	. . . . .	. . . . .	20	123	54	61	280
19	Met. W. W., Mass.	874 200	874 200	874 200	54 884 545	. . . . .	. . . . .	. . . . .	20	123	54	61	280
20	Met. W. W., Mass.	{ T'n 7 000 D'n 4 400 }	4 100	3 900	39 152 660 000	. . . . .	. . . . .	. . . . .	20	123	54	61	280
21	Middleboro, Mass.	18 000	14 000	12 500	1 709 855 000	. . . . .	. . . . .	. . . . .	42	61	280	18 00	43 00
22	Middletown, Conn.	225 000	150 000	135 000	456 250 000	. . . . .	. . . . .	. . . . .	15	100	657	16 94	49 96
23	Minneapolis, Minn.	70 000	62 000	61 000	7 094 120 905	. . . . .	. . . . .	. . . . .	23	144	104	16 94	49 96
24	New Bedford, Mass.	19 000	17 800	16 800	2 325 807 038	. . . . .	. . . . .	. . . . .	27	78	390	166 10	16 16
25	New London, Conn.	36 400	35 700	35 400	478 475 000	. . . . .	. . . . .	. . . . .	62	54	264	59 60	91 16
26	Newton, Mass.	4 800	4 000	3 000	703 495 793	. . . . .	. . . . .	. . . . .	37	45	183	140 14	305 16
27	Oberlin, Ohio	198 400	198 400	198 400	48 837 000	. . . . .	. . . . .	. . . . .	60 ¹	58	508	16 58	21 29
28	Providence, R. I.	5 000	14 860	4 385	4 220 646 056	. . . . .	. . . . .	. . . . .	34	107	512	16 58	21 29
29	Reading, Mass.	84 060	83 800	83 980	53 269 837	. . . . .	. . . . .	. . . . .	34	107	512	16 58	21 29
30	Reading, Pa.	43 902	42 312	42 312	3 292 453 769	. . . . .	. . . . .	. . . . .	34	107	512	16 58	21 29
31	St. John, N. B.	43 902	42 312	42 312	2 531 593 800	. . . . .	. . . . .	. . . . .	22	146	139	16 58	21 29
32	St. John, N. B.	43 902	42 312	42 312	2 531 593 800	. . . . .	. . . . .	. . . . .	22	146	139	16 58	21 29

	1. Permanent population.	2 In summer.	3 Based on meters.	4 Estimated.	5 School census.	6 Domestic.	7 Pulp mill, etc.
33	Somerville, Mass.	65 500	65 500	354 171 716	..	8 300 000 ⁴	...
34	Springfield, Mass.	64 675	51 000	464 341 248	15	1 534 740	...
35	Taunton, Mass.	31 036	27 000	245 734 618	44	2 435 332	...
36	Waltham, Mass.	24 950	24 550	51 485 950	6	338 163	...
37	Ware, Mass.	8 263	7 690	74 250 636	60	257 001	...
38	Wellesley, Mass.	5 240	5 147	48 377 249	52	605 300	...
39	Westerly, R. I.	11 500	9 000	..	...	122 235	...
40	Whitman, Mass.	6 434	...	44 615 667	..	95 667	...
41	Winchendon, Mass.	5 300	2 576	12 888 890	37	1 218 307	...
42	Woburn, Mass.	14 250	14 200	41 255 670	9	989 423	...
43	Woonsocket, R. I.	34 974	34 474	278 268 469	77	4 540 924	...
44	Yonkers, N. Y.	52 000	51 000	880 882 333	53	89	...

¹. Permanent population.

² In summer.

³ Based on meters.

⁴ Estimated.

⁵ School census.

⁶ Domestic.

⁷ Pulp mill, etc.

1902.—TABLE 4.—STATISTICS RELATING TO DISTRIBUTION SYSTEM.—MAIN PIPES.

Number.	Name of City or Town.	1 Kind of Pipe.	2 Sizes of Pipes. (Inches.)		3 Length Extended During the Year. (Feet.)	4 Length Discor- tinned During the Year. (Feet.)	5 Total Length in Use. (Miles.)	6 Cost of Repairs per Mile.	7 Number of Leaks per Mile.	8 Length of Pipe Less than 4 Ins. (Miles.)	HYDRANTS.		GATES.		15 Range of Pressure on Mains. (Pounds.)	
			Total in Use.								Total in Use.		Number Added.	Number Smaller than 4-Inch.		Number of Blow-off Gates.
1	Atlantic City, N. J.	C. I.	4	-20	21 625	450	54 8	..	..	2 6	41 ¹	592 ¹	73	..	4	40-55
2	Attleboro, Mass.	W. I., C. I., Cem. L.	1	-16	30 729	..	39 0	..	0 5	..	29	307	27	736	1 13	54-62
3	Bay City, Mich.	C. I., Wyckoff.	4	-20	14 848	5 609	47 3	\$20 15	1 4	0 5	13	430	27	736	1 13	35-100
4	Belmont, Mass.	C. I.	4	-12	613	0	18 0	..	0	..	1	141	1	215	19 11	15-100
5	Billerica, Mass.	C. I.	6	-12	..	..	9 7	2 12	1	0 5	1	101	..	84	4	54-120
6	Brookton, Mass.	W. I., Cem. L., C. I.	6	-30	29 579	0	74 4	2 62	0 4	0 7	46	696	69	917	10 29	47-56
7	Burlington, Vt.	Cem. L., W. I., C. I.	4	-30	4 835	2 244	39 0	8 18	0 7	2 7	1	214	19	652	60 14	70-85
8	Cambridge, Mass.	C. I.	2	-40	4 392	..	125 1	1 23	0 02	3 3	23	1 001 ¹	39	..	..	45-55
9	Chelsea, Mass.	C. I.	4	-16	1 650	..	38 8	..	3	0 1	5	290	7	416	0 31	50-75
10	Cleveland, Ohio	C. I., Steel.	3	-48	86 567	17 836	577 0	..	..	2 5	186	6 648	341	12465	6	20-80
11	Concord, N. H.	C. I., Cem. Lined.	6	-24	15 622	12 466	61 8	..	..	..	5	277	17	800	..	50-75
12	Fall River, Mass.	C. I.	2	-30	12 956	..	92 8	..	..	..	40	1 031	34	1 020	..	80
13	Fitchburg, Mass.	C. I.	2	-30	2 502	..	68 0	..	..	..	4	516	9	573	..	75 L. S. 155 H. S.
14	Holyoke, Mass.	W. I., C. I., Cem. L.	4	-30	2 300	0	83 3	7 44	0 05	5 7	7	771	13	792	15 31	45-100
15	Lawrence, Mass.	C. I., Id. Lined.	1	-30	11 264	3 953	81 9	..	..	7 7	16 ¹	773	44	039	0 12	65-125
16	Lowell, Mass.	..	..	..	13 369	..	131 9	..	..	..	..	1 120	54	1 289	..	..
17	Lynn, Mass.	Cem. Lined, C. I.	4	-36	3 940	..	132 5	136 00	1 61	..	1	963	15	992	..	40-60
18	Madison, Wis.	C. I.	4	-8	12 374	..	38 3	..	..	..	19	194	14	260	2 2	53-65
19	Maynard, Mass.	C. I.	4	-12	2 595	..	9 5	0 99	0 5	0	2	90	5	85	0 2	90-95
20	Met. Water Works Met. Water Dist. total in cities and towns.	C. I., C. L.	6	-60	53 300	..	82 1	..	..	..	..	..	48	328	..	..
21	Middleboro, Mass.	C. I., C. L., Kal.	4	-60	320 000	..	1 457 1	..	..	654	12 933	..	..	..	..	..
22	Middletown, Conn.	C. I.	4	-12	1 766	1 230	17 3	..	..	0 6	0	121	3	178	0 6	40-60
23	Minneapolis, Minn.	C. I., W. I., Steel.	6	-50	11 618	0	31 3	70 11	..	1 3	0	209	12	268	18 45	40-125
24	New Bedford, Mass.	C. I.	4	-36	18 433	2 507	97 9	8 08	0 14	1 1	43	979	45	1 137	78 97	25-95
25	New London, Conn.	Cem. Lined, C. I.	4	-24	24 520	48	57 8	5 67	0 33	3 3	19	328	25	366	48 34	40-48
26	Newton, Mass.	C. I.	4	-20	4 380	0	138 7	2 00	0 05	3 3	2	963	6	815	48 392	80-86
27	Oberlin, Ohio.	C. I.	4	-12	3 856	..	10 4	0	0	0 3	7	96	6	66	2 2	27-32

28	Plymouth, Mass. . . .	Cem. Lined, W. I.	2 -20	6 031	1 818	45 6	17 16 1 77	10 9	6	186	10	461 138	36	64-73
29	{ Providence, R. I.	C. I.	6 -36	28 240	1 199	336 2	0 77 0 08	0	41	1 960	54 3	530 0	32	114
30	{ H. P. Fire Service.	C. I.	12-24			5 6			0	92		31	4	
31	Reading, Mass. . . .	C. I.	6 -12	2 270		28 5	0 48 0	0	2	163	5	248 0	14	63-78
32	Reading, Pa. . . .	C. I.	11-36	24 611	19 227	102 7	17 42 0 55	0 8	58	818	162 2	457 9	133	10-133
33	St. John, N. B. . . .	C. I., W. I., Cem. L.	1 1/2 -20	6 842	0	49 4	9 66 0 78	1 9	0	392	61	195 126	123	11-77
34	Somerville, Mass. . . .	C. I.	4 -20	6 622	2 536	87 8	2 85 0 16	7 9	31	999	35 1	283	89	60-100
35	Springfield, Mass. . . .	C. I., W. I., Cem. L.	1 -36	8 449	0	147 3	5 95 0 24	1 7	9	972	59 1	983 403	89	30-120
36	Taunton, Mass. . . .	C. I.	4 -30	3 580	0	79 89	29 58 0 21	2 2	6	803	7	570 12	59	45
37	Waltham, Mass. . . .	C. I., Cem. Lined.	2 -24	10 305	8 546	52 0	2 56 0 2	0 8	1	350	16	711 39	60	50-70
38	Ware, Mass. . . .	C. I.	4 -12	2 336	0	12 2		0 8	1	117	2	123 11	3	90-95
39	Wellesley, Mass. . . .	C. I., Cem. Lined.	4 -12	1 450	3 100	30 8	0 54 0 6	0 2	3	285	3	228 3	4	70-75
40	Westerly, R. I. . . .	C. I.	4 -12	46 902	0	31 6	0 16		25	149	50	184	7	82-92
41	Whitman, Mass. . . .	C. I., Cem. Lined.				17 5	0			157	2	92		65
42	Winchendon, Mass. . . .	C. I., W. I.	2 -14	4 933		17 5		2 0	3	134	5	180 30	18	40-151
43	Woburn, Mass. . . .	Cem. Lined, C. I.	4 -14	2 319		54 4	15 29 0 53	5 0	4	358	4	427 51	16	70-75
44	Woonsocket, R. I. . . .	C. I.	4 -20	7 108		48 0	1 22 0 12	0 8	12	571	17	475 0	15	50-120
45	Yonkers, N. Y. . . .	C. I.	3 -30	22 070	3 484	88 8	14 03 0 9	0 8	51	909	33	583 3	24	45-130

1 Public hydrants only.

29	Providence, R. I.	Lead, C. I.	1-10	2 566	222 15 0	591	22 758	70	42 47	717 19 216	84	100	4	169
30	Reading, Mass.	C. I., Cem. L'd., Ld. L'nd.	1-6	1 800	31 4	661	17 603	23 00	138	31 1 018	89	25	0	3
31	Reading, Pa.	Ld., W. I., C. I., Ld. L'nd.	1-8	7 569	68 2	52	5 735	29	23 00	138	952	5	1	9
32	St. John, N. B.	Ld., W. I., C. I., Cem. L'd.	1-4	1 800	31 4	190	10 710	..	18 82	45	195	3	0	12
33	Somerville, Mass.	Ld., Ld. L'nd, Cem. L'nd.	1-6	1 800	31 4	190	10 710	..	18 82	45	269	3	1	9
34	Springfield, Mass.	Ld., Cem. L'nd, Farred I., G. I., C. I.	1-6	1 800	31 4	190	10 710	..	18 82	45	269	3	1	9
35	Taunton, Mass.	Cem L'nd, Fin Lined.	1-6	1 800	31 4	190	10 710	..	18 82	45	269	3	1	9
36	Waltham, Mass.	C. I., W. I.	1-12	4 800	7457 45 4	101	4 698	..	52 21	116	2 050	44	0	17
37	Ware, Mass.	Cem. Lined, W. I.	1-2	5 498	2125 40 4	54	3 406	59	30 26	110	200	6	0	6
38	Wellesley, Mass.	C. I., Cem. L., Lead L'nd.	1-6	1 540	845 9 8	23	780	62	..	24	778	100	0	9
39	Westerly, R. I.	Lead, W. I.	1-4	3 067	5994 15 4	-5	893 122	..	13 02	23	877	100	0	0
40	Whitman, Mass.	W. I.	1-4	..	..	228	1 375	..	10 43	208	1 088	79	3	11
41	Winchendon, Mass.	W. I.	1-2	1 885	4 4	22	1 030	..	..	..	490	48	..	..
42	Woburn, Mass.	Lead L'nd, Cen. Lined.	1	1 885	4 4	52	497	48	18 86	40	474	95	0	0
43	Woonsocket, R. I.	Lead, C. I.	1-6	1 944	0 7 0	31	2 962	..	14 45	3	72	2	..	9
44	Yonkers, N. Y.	Lead, C. I.	3-8	..	..	130	2 441	14	14 28	115	2 118	87	1	13
				..	..	257	5 495	..	..	248	5 404	98	..	..

THE FOLLY OF RECKONING BY GALLONS, WHICH
DIFFER WIDELY IN CANADA AND THE UNITED
STATES, WHILE ALL COUNTRIES HAVE IDENTI-
CAL LITERS AND CUBIC METERS.

BY FREDERICK BROOKS, C. E., BOSTON, MASS.

[Presented September 10, 1903.]

This subject is commonplace and hackneyed. It suggests that what has been before this convention should be reviewed from the metrological standpoint. The facts are familiar; and for that reason their importance may fail to be appreciated unless especial effort be made to draw attention to them. Many, perhaps most, of the wrong things that we do are caused by thoughtlessness rather than depravity; and it is desirable that we take advantage of being away from home to see facts in a new light. We are not merely out of New England, but out of the United States; let us look at ourselves from the outside and see ourselves as others see us. For the first time as an Association we are in Canada. Canada is an intermediary between Old England and the United States, being closely connected politically with one and geographically with the other; and she is well situated for leadership, as she has left both those countries behind.

DECIMALIZATION.

In this city of Montreal last month the great Congress of Chambers of Commerce from all parts of the British Empire passed a resolution recommending to the British government decimal coinage for the empire. In decimalization Canada and the United States have left England behind, having adopted dollars and cents and abandoned the pound, shilling and penny reckoning which they formerly used and which England continues to use. Money deserves prominent mention because of the very close analogy that exists, extending into many details, between the change in monetary reckoning and the change in weights and measures.

Our decimalization has included other things along with money; for instance, our discussion yesterday brought out the fact that Canada has adopted a ton of 2 000 pounds, which in England is called the "colonial" ton, so that the hundredweight in America is 100 pounds, not as in England 112. We have reckoned lumber by the thousand feet of board measure, instead of cubic feet, cubic yards or cords, etc.; and slating or shingling by the "square" of 100 square feet, disregarding square yards; and so on. In reality our decimalization has been less an establishing of special units than a mental habit of reckoning conformably to our "Arabic" notation; and that habit has had markedly wider exercise in America than in England. I doubt if any kind of measure can be named in which multiplying or subdividing by ten has not been introduced as a practice among us. Try such as pertain to water works. At this convention we have had some mention of annual rainfall. Those people who are sure that 12 inches used to make a foot and that the inch was divided by successive bisections hear no more of a rainfall of 4 feet $3\frac{1}{2}$ inches than they do of a barometric reading of 2 feet $5\frac{1}{8}$ inches. We might have a rainfall of 51.62 inches in a year. We have stuck to the inch and used our decimal notation for expressing multiples of the inch up to very high figures; and we have insisted upon writing fractions decimally. With cast-iron water pipes it has been similar. We have heard praise given, as was deserved, to this Association's committee which recently reported on Standard Specifications and submitted extended tables of dimensions of pipes. Diameters go up to 65.20 inches and thicknesses go down to 0.34 of an inch; but there is no eighth inch or sixteenth inch as formerly written, and no foot expression of transverse dimension. Consumption of water has afforded another instance of the same kind. We have adhered to the little unit of a gallon even for immense quantities. The million of gallons, a number too large for the human mind to picture adequately to itself, we have practically made our unit of higher denomination, ignoring the various multiples of the gallon that belonged to our old tables of measures. For instance, it has been exceptional with us to express consumption by the barrel, as in the statement made this morning in Mr. Venner's paper, that, on the average, two-thirds of a barrel of water per day was disposed of for every pupil in the school-houses of Syracuse, N. Y.

In irrigation, quantities have sometimes been expressed by the acre-foot. In both these cases the attempt was probably to use familiar units of which mental conception could be formed. As for small quantities, we have in Table No. 2 of Mr. Kimball's valuable paper on "Test of Water Meters" put before us this morning, two decimals of gallons, the tenth of the gallon and the hundredth of the gallon; he does not use the binary subdivisions — the pint and gill well known to people generally.

RELATIONSHIP.

It is all very well to note that we left Old England behind. It is less flattering to our vanity, but more useful, to take up the point in which we were left behind by Canada and England. This was in the establishment of systematic relations between units, especially the relation of capacity measure to weight of water. Water was taken for the basis, not out of compliment to water-works men, but as generally recognized to be the proper reference in both ancient and modern weights and measures. It is the standard for comparison in the expression of specific gravity. The British Imperial gallon was made to hold 10 pounds of water; going upwards and downwards,—

The peck	holds	20 pounds.	The quart	holds	$2\frac{1}{2}$ pounds.
The bushel	"	80 "	The pint	"	$1\frac{1}{4}$ "
The quarter	"	640 "	The fluid ounce	"	1 ounce (Av.)
etc.			etc.		

Simple relationship has thus been established between such of these units as are specially used for dry measures and such as are specially used for liquids. In the British Pharmacopœia, the reference manual of the apothecary, the avoirdupois ounce was introduced. The United States was left with what Great Britain long ago abandoned, separate liquid and dry measures without any simple precise relations; the name of quart we have applied sometimes to a dry measure and sometimes to a different measure for liquids. We thought less of this long-standing difference while pursuing our routine work at home than we do on coming here and listening to Mr. Janin's interesting account of the Montreal Water Works and running up against consumption expressed in gallons about 20 per cent. larger than our United States measure. It is here, where we have Canadian members with minds accustomed to

Imperial gallons, that Mr. Kimball's paper is presented with its tables full of our smaller United States gallons. The question naturally arises, What was the use of translating the results into gallons at all? The water meters Mr. Kimball tested read in cubic feet, the same in Great Britain, Canada, and the United States. He uses cubic feet in two different parts of his discussion besides the paragraph referring to the dials of the water meters. That gallons can be dispensed with in accounts is illustrated by President Walker's speaking here of a price per 100 cubic feet for water consumed. The latest edition (October, 1902) of Trautwine's "Civil Engineer's Pocket-Book" has four pages occupied with long figures for the interconversion of discharges in cubic feet per second and millions of gallons per day, both United States and Imperial, an instructive exhibit of the needless labor that has been imposed upon us by the diversity of our reckonings. An amusing instance of conflicting gallons appears in the August, 1903, Proceedings of the American Society of Civil Engineers; a paper on South African irrigation mentions the price of "Homelight" kerosene oil as 11 shillings per case of $8\frac{1}{2}$ Imperial gallons; Yankee readers may guess that it was 10 United States gallons when the case started from home.

In reality, our mental habit, even in the United States, has been to insist upon having relationship, if not simple and precise, then cumbrous and approximate. Let us briefly notice some relations that had to do with water. In their origin the old measures had relationship which has long lost any precision it ever had. Eight gallons went to the bushel and a gallon was 8 pounds; according to that a quart was 2 pounds, and there was reason in the first half of the old rhyme, "A pint's a pound the world around." The United States fluid ounce, or 16th part of a United States pint, has held a weight of water about 5 per cent. less than the ounce weight used in the United States Pharmacopœia, and over 4 per cent. more than the avoirdupois ounce. The "tun" also bears witness to ancient relationship. As nearly as I have found out, the word "tun" meant something rounded, like a tunnel, a cask. Since for centuries commerce has included large shipments of several liquids besides molasses in large casks, the capacity of vessels has been expressed as tunnage or tonnage; and with their burden in tons we have set up a corresponding large unit of weight. We still

read in our arithmetical tables that four hogsheads make 1 tun and that the barrel is half a hogshead and is $31\frac{1}{2}$ gallons; the hogshead, or fourth part of the tun, contains 252 quarts according to this liquid measure. Another measure, called the "quarter," containing 256 quarts or 8 bushels, and appearing to have been similarly connected with the tun or ton, has continued in use from ancient times in England, having been a very well-known unit in the grain trade; its name and approximate magnitude are preserved in the Imperial measure as just above stated.

We have carried in mind a number of other relations which, though untrue, were well invented; as that $7\frac{1}{2}$ United States gallons, or 30 quarts, were equivalent to a cubic foot; a cubic foot of water, to a thousand ounces; $1\frac{1}{2}$ cubic feet per second, to a million United States gallons per day; and the water contained in an inch pipe a yard long, to a pound.

SYSTEM ADOPTED.

Our two mental habits have free play in the metric system. Instead of our ancient division of a tun into 8 barrels, we now decimalize, and regard the nearly equivalent metric ton of water as consisting of 10 hektoliters, that is to say, ten hundred liters, and the quarter part of it as 250 liters and not 256 quarts (quarter) nor 252 quarts (hogshead). Forgotten relationship is restored. The liter, being between United States quart and British quart, between liquid quart and dry quart, between wine quart and beer quart, we naturally think of it as a quart. Everybody knows the size in the form of a bottle, and knows how much its weight is reduced by the extraction of its liquid contents. That furnishes the commercial unit of weight, the kilo, or thousandth part of the ton. The name "liter" corresponds with *litron*, a measure of nearly the same capacity in the series of dry measures formerly in use in Belgium, in France, in Louisiana until its cession to the United States 100 years ago, and here in Canada, where its use was for a long time established by British authority; for aught I know it may still be remembered here. The kilo of water or the liter, if in cubical shape, is the cube of 1 decimeter, the measure of a length which is perfectly familiar to us all, being practically the same as the "hand," the unit of measurement of height of horses. The width of common bricks is nearer to 1 decimeter than to 4 inches. The ordinary dimension of scantlings is nearer to 1

decimeter than to 4 inches. One decimeter might have been as correctly used as 4 inches to designate the diameter of the pipes that make up a greater length than any other size in the schedule of cast-iron mains in this city submitted to this convention yesterday by Superintendent Janin; for the difference between the two may be neglected in view of the variations made in the actual interior diameters of pipes of the same nominal size. That metric measure can easily be applied to existing water-pipe sizes was mentioned in a discussion by George E. Manning when the report of the Committee on Standard Specifications was under consideration, as published a year ago in the *JOURNAL* of the N. E. W.W. A., vol. 16, p. 133. The metric ton of water, or ten hundred liters, if in cubical shape, is the cube of 10 decimeters or 1 meter, the fundamental unit of length; and so on. The relationship extends throughout the system instead of being, as with old measures, exceptional, fictitious or obsolete. We have the same basis for measurement of excavation, of structural work, and of everything else, as for quantity of water. If we dig out a number of cubic meters of earth for a well, that number of cubic meters of water will fill it to the brim. If we build a tank to metric dimensions and compute its capacity as a number of cubic meters, it will hold that number of tons of water. If our filter beds take care of 1 000 cubic meters per hektar, that's 100 liters per square meter, or a subsidence of 1 decimeter measured vertically. Decimal multiplying and subdividing likewise extends throughout the system, instead of being, as with old measures, forced in where it conflicts with what is customary. If for every child in the Syracuse schools there is an average of 83 liters of water per day disposed of, it is needless to add the separate statement that it is 83 per cent. of a hektoliter. If the irrigation engineer has in his mind's eye a meter's depth of water over the area of a hektar, that is 10 000 cubic meters, or 10 000 000 liters. Trautwine has three pages mostly occupied with figures for the interconversion of expressions of pressure in pounds per square inch, pounds per square foot, and head of water in inches and in feet; the exclusive use of the metric system would make these pages unnecessary, for the moving of the decimal point does not require a table of long figures to exhibit it; a pressure of 1 kilo per square centimeter or 10 metric tons per square meter corresponds to a head of 1 000 centimeters, or 10 meters, of water.

Trautwine has a table of about a page for the conversion of inches and 32ds into feet and decimals, which could be dispensed with if all multiples and subdivisions went by tens; he has no table for the conversion of cents and mills into decimals of a dollar.

Our inflexible adherence to the two mental habits above spoken of would have sufficed to account for our having adopted the metric system, even if we had not been forced into it by other considerations, especially the development of electricity and the growth of international trade. Here in Montreal three weeks ago the Congress of Chambers of Commerce of the British Empire passed a resolution favoring the completion of the introduction of the metric system throughout the empire. The publishers of the *Canadian Engineer*, having an office in this city, have published a metric chart, a copy of which is displayed in the exhibition room for water-works appliances in connection with this convention. The latest revision of the British Pharmacopœia has introduced metric weight and measure throughout. The United States Pharmacopœia has gone further and completed the transition by omitting the old medley; incongruous ounces, scruples, minims, and all are abandoned. We can hardly take up a newspaper or periodical that has not some use of metric weights and measures in it. The system hits us on every side, including the water-works side. The new edition (1903) of Professor Merriman's "Treatise on Hydraulics" introduces metric data and tables along with the old units. The plan of the Lawrence filter that Mr. Collins showed us this afternoon had figures upon it in millimeters for the sizes of sand. The paper and discussion on the Physical Properties of Water and Turbidity in the N. E. W. W. A. JOURNAL of March last were mostly in metric measure. The recent official publication of the report of the water purification investigation at New Orleans, of which Mr. R. S. Weston gave us an interesting account at one of our meetings last winter, shows extensive use of the metric system as well as of ancient weights and measures. It is a significant fact that the latest edition (October, 1902) of Trautwine's "Civil Engineer's Pocket-book" has fifty pages devoted to the subject of weights and measures; its extended treatment is appropriate to the present requirement for accurate translation of old reckonings into the metric system. For approximate translations, such as we have

to make in our heads, a revised table is submitted herewith. (See page 267.) It is the easier to remember, because the same ratios are used repeatedly; familiar relations, exact or inexact among the old measures are adhered to, and equivalents are carefully grouped. As the hand is practically a decimeter, the yard, being 9 times as long, is 9 decimeters. The American, or net, ton is less than the English, or gross, ton by over 10 per cent.; as the English is about the same as the metric, the net ton corresponds to 9 hektoliters of water or 900 kilos. We remember the net ton as 2 000 pounds, the peck of water as 20 pounds and the United States liquid quart as 2 pounds; that is, the peck is a hundredth of the net ton and is 9 liters, while the United States liquid quart is a tenth of the peck and is 0.9 of a liter or of a cubic decimeter. The cubic foot is 30 quarts, hence 30 times 0.9, or 27, cubic decimeters; and, if of water, weighs 27 kilograms. The ounce, or thousandth part of the cubic foot of water, is then 27 grams. The smaller figures inserted in parentheses are accurate enough for use in business transactions.

WHAT ARE YOU GOING TO DO ABOUT IT?

There are a number of things to be done. Let each of us post up in his office a metric chart, the *Canadian Engineer* publishers' or any other. Let it be the rule that any plan of importance enough for a linear scale shall have a metric linear scale, and let this rule be enforced upon any plans published in the JOURNAL of the N. E. W. W. Association. Let us make known to the Secretary of the Treasury of the United States that we wish the metric system to be exclusively used in the customs service from the earliest possible moment. The thing which I have particularly to speak about is that the form recommended in this Association for water-works statistics should provide for the expression of consumption of water in metric measure, whatever other equivalent expression may be allowed along with it for a little time to come. The Association's purpose in having a Committee on Uniform Statistics is obviously to get the water works of the different cities and towns of New England to use the same form in making up statistics, so that they may be readily comparable. The same idea requires, for the sake of comparing with places outside of New England, that the form should agree with what is used else-

where. This Association has members in Canada and England, and they have statistics in gallons about 20 per cent. larger than the United States gallon. What these three countries have done to promote uniformity is to establish the international metric system, the same in the English-speaking countries and also in the non-English-speaking countries. We hear of the number of bacteria per cubic centimeter in the water supplies of continental Europe as well as of Great Britain and America. Mr. Metcalf has come back from Porto Rico and told us this evening of the metric system having been used on the military road there. There are other parts of the world where Spanish, Dutch, Japanese, and other languages are spoken, and where there are water works from whose statistics we might sometime learn by comparison.* It has been announced upon our program that a report from our Committee on Uniform Statistics is in order following this discussion of mine. I have accordingly taken the liberty of addressing notes to the members of that committee, inviting them either to report a recommendation that metric capacity measure be introduced for the expression of quantities of water consumed in the Association's form of statistics, or else to participate in the discussion of this topic and explain why not.

* As this discussion is being revised for the printer, the September number of *Proceedings* of the American Society of Civil Engineers is issued, containing a paper of fifteen or twenty pages on Filtration for Public Water Supplies, with Especial Reference to the Double Filtration Plant at Bremen, Germany. The paper is written in metric measure throughout, and contains scarcely any mention of the ancient method of reckoning.

APPROXIMATE EQUIVALENTS.

LENGTH.			AREA.		BULK.	
1 inch and	2½ centimeters	(2.54)	1 sq. inch and	6¼ sq. centim's	1 cu. inch	and 15½
1 foot "	0.3 of meter	(.3048)	1 sq. foot "	0.09 of sq. meter	1 cu. foot	cu. centimeters
1 Yard "	0.9 " Meter	(.9144)	1 sq. yard "	0.81 " "	1 cu. yard	0.027 of cu. meter
1 rod "	5. meters	(5.029)			100 cu. feet	0.729 " "
1 chain "	20. "	(20.117)	1 sq. rod "	25. sq. meters	(The unit of ship's measurement for register.)	2.7 " "
1 furlong "	200. "	(201.17)	1 acre "	1000. "	1 M board meas. and 2 ¼	cu. meters . . .
1 mile "	1600. "	(1609.3)	1 sq. mile "	256. hektars	1 cord	3.6 " "
WEIGHT.			and 0.45 of kilo		1 U.S. liq. pint	
			1 pound	(.4536)	1 " "	0.45 of liter . . .
			60 lbs. (wheat bu.)	(27.216)	1 " "	0.9 " Liter . . .
1 grain and .004 of gram	(.0648)		80 lbs. (coal bu.)	(36.287)	1 " "	3.6 liters . . .
1 troy ounce " 30. grams	(31.103)				1 peck "	9. "
1 avoird. " " 27. grams	(28.35)		112 lbs. (cwt.)	(45.36)	1 bushel	" "
			1 Net Ton	(50.8)	1 ton of ship's displacement	(U.S. 8.81; Br 9.09)
			1 gross ton	(907.2)		(U.S. 35.24; Br. 36.37)
				(1.016)		1 cu. meter.
COMBINATIONS.			1 horse power		POWER.	
				and ¾ of kilowatt		(.746)
1 foot-ton (net)				" 0.27 " (metric) ton-meter . . .		(.2765)
1 foot-pound				" 0.13½ " kilogrammeter		(.1383)
1 pound per running yard				" ½ kilo per running meter . . .		(.4961)
1 " " " foot				" 1 ½ kilos " " " "		(1.4882)
1 pound per sq. foot				" 5. kilos per square meter . . .		(4.882)
1 net ton " " "				" 1. kilo per sq. centimeter . . .		(0.9765)
15 lbs. " " inch				" " " " " "		(1.0546)
1 pound " " "				" 0.07 " " " "		(.0703)
1 net ton " " "				" 0.14 metric ton per sq. centimeter		(.1406)
1 pound per cu. foot				" 16. kilos per cu. meter		(16.02)
						WEIGHT PER BULK.

MUNICIPAL USE AND WASTE OF WATER.

BY JOHN VENNOR, CHIEF INSPECTOR, BUREAU OF WATER, SYRACUSE, N. Y.

[Read September 10, 1903.]

Mr. President and Gentlemen: — At almost every meeting of this Association there is a discussion of the questions of waste of water by private consumers and the stealing of water from fire services, together with suitable suggestions as to how to prevent the same. On these questions I think that all agree that the meter should be the only arbitrator.

There seems, however, to have been too little attention given to the matter of "municipal economy" in the use of water. This has led me to believe that the subject of waste in public buildings would be of interest to you.

With the rapid growth of cities the difficulty of obtaining and maintaining an adequate supply of good water becomes a very serious one. Many cities have had to go long distances for their supplies, spending large sums of money in the building and maintenance of conduits. Careless and unrestricted use of water causes these conduits to reach the limit of their capacity long before they should, and necessitates the building of new lines. It is safe to say that nearly all cities have an enormous expense in pumping considerably more water than is needed for legitimate use.

Many of the members of this Association are familiar with the water-works system of the city of Syracuse. For the benefit of those who are not, I will give a brief description of our water supply.

We obtain our water from Skaneateles Lake, about 19 miles distant from the city. This lake is a feeder of the Erie Canal, and special legislation was necessary before it could be used by the city. A vast amount of opposition was encountered, and when the state finally consented to its use by the city the size of the supply conduit was limited to 30 inches in diameter. The amount of water that this conduit will discharge is estimated to be about 14 000 000 gallons daily.

The average daily consumption is fast reaching this limit, there having been nearly 12 000 000 gallons used daily during the year

1902. This condition of affairs has made it necessary for the city to take steps to reduce the consumption by stopping all waste possible, thus prolonging the usefulness of the present conduit. This led to a study of methods by which this reduction could be accomplished.

It was in this connection that I took up the matter of public waste, commencing with the public schools.

There are thirty-four of these buildings, and all have been metered since February, 1903.

The following table shows the daily consumption of water per pupil, in gallons, based upon the average daily attendance in each school:

DAILY CONSUMPTION OF WATER PER PUPIL IN THE PUBLIC SCHOOLS OF SYRACUSE, N. Y., FOR THREE MONTHS OF 1903.

<i>School.</i>	<i>Average daily attendance.</i>	<i>Per capita consumption, in gallons.</i>		
		<i>March.</i>	<i>April.</i>	<i>May.</i>
1 Jefferson	314	17.8	21.1	24.1
2 Grant	304	22.2	25.2	24.4
3 Townsend	481	5.4	5.7	5.5
4 Garfield	434	5.1	6.6	5.2
5 Franklin	826	4.1	3.5	2.4
6 Prescott	574	9.4	9.2	6.
7 Clinton	522	16.2	15.3	14.7
8 Lincoln	414	9.1	8.	7.8
9 Vine	218	2.3	4.2	4.1
10 Frazer	428	12.8	14.2	11.
11 Genesee	412	6.	3.2	2.9
12 Commercial	86	397.	381.	497.
13 May	426	110.	114.	117.
14 Tompkins	388	5.6	6.1	8.7
15 Porter	778	4.5	4.5	3.2
16 Gere	352	33.	33.5	22.5
17 Madison	529	40.7	39.4	32.8
18 Sumner	358	20.9	20.	15.7
19 Washington Irving	439	35.3	30.9	22.6
20 Willard	81	188.8	190.9	104.4
21 Montgomery	471	5.1	4.1	4.0
22 Putnam	650	21.6	16.7	12.6
23 Andrew Jackson	353	3.5	2.9	3.9
24 Croton	605	44.5	31.2	28.
25 New High School	1 267	8.9	9.4	9.0
26 Seymour	665	26.3	23.6	23.6
27 Truant School	16	22.3	38.2	52.2
28 Delaware	523	7.5	9.2	6.6
29 Grace	259	16.8	24.3	30.9
30 Merrick	294	35.6	17.9	22.3
31 Bellevue	257	32.1	32.8	37.9
32 Danforth	348	25.9	21.4	22.
33 Elmwood	224	8.4	14.5	14.5
34 Brighton	868	5.3	4.1	3.

The wide variance in daily consumption in the different schools, ranging from 2.3 gallons to 497 gallons per pupil, shows plainly that in some there must be very large waste.

The average daily consumption in the public schools for the months of March, April, and May was about 20 gallons, or two-thirds of a barrel of water for each pupil.

The average number of gallons used daily in all of the schools for the three months mentioned was about 450 000, or 3.6 per cent. of the city's entire consumption, and represented a value, figured at the usual rates, of about \$1 000 per month. The Bureau of Water receives no compensation from the city for water used for municipal purposes.

Prior to the introduction of meters in school buildings little or no effort apparently was made to prevent waste of water through defective fixtures, and such waste not only occurred during the time that schools were in session, but also was allowed to continue during vacation periods. Since the placing of the meters the water has been turned off from the buildings during all vacations. This fact makes it evident that the use of water in the schools before they were metered was even greater than the above table shows.

There is no doubt that most of the waste in schools is due to lack of proper care of plumbing and to carelessness of children in leaving water running from the faucets.

As a remedy for the first condition I would suggest that a thorough inspection of each school be made with regard to the condition of the fixtures, and to ascertain what conditions there are that might tend to increase or decrease the legitimate use of water; and that from this basis a reasonable per capita consumption for each school be arrived at. Whenever this consumption is exceeded to any large extent the school officials should be held responsible. Through the hearty coöperation of both water and school officials in this matter, I have no doubt that there could be effected a very large saving of water.

To prevent carelessness in leaving water running unnecessarily I would suggest that, wherever it is possible, all faucets in schools be required to be of the self-closing style.

These measures are to be carried out in the city of Syracuse.

The same conditions that exist in the school buildings doubtless

exist in other public buildings, and we are now engaged in placing meters on engine houses, public baths, etc.

In this paper I have not gone as deeply into this subject as I might, as I intend, at some later meeting of the Association, to give you our experience in detail, covering fully the use of water in all of our public buildings, parks, etc., as well as for watering troughs, street sprinkling, and flushing of pavements.

HISTORY AND DESCRIPTION OF THE MONTREAL WATER WORKS.

BY GEORGE JANIN, C. E., SUPERINTENDENT MONTREAL WATER
WORKS.

[*Read September 9, 1903.*]

On the occasion of the convention of the New England Water Works Association in Montreal, the author thought it would be interesting to the members of the Association to give a brief history and description of the Montreal Water Works.

A few introductory words regarding the city of Montreal will not be out of place, before describing the aqueduct system.

The city of Montreal was founded in 1642, when Canada was under French domination, but it was some years before the town, on account of its industrial and commercial importance, assumed the dignities of the metropolis of the country. Montreal's attainment to this distinction is the result of its commanding geographical position on the banks of the St. Lawrence River, at the terminus of ocean navigation.

Montreal possesses a salubrious climate; it is very cold in winter according to the thermometer readings, but owing to the lack of humidity in the air, the cold is not merely tolerable but pleasant.

The area included in the limits administered by the city corporation is about 6 000 acres, containing a population of 266 466 souls, not counting any of the large suburban municipalities, which are not separated from the city by any natural boundary but really form part of the city, and which, if annexed to the city, as they soon must be, would bring the population to 350 000 souls.

The water supply of the city, with the exception of St. Denis Ward, is under the control of the municipal administration, which owns the aqueduct and imposes a rate for payment. St. Denis Ward and the suburbs are supplied from a private company, the Montreal Water and Power Company.

As for all old cities, the aqueduct of Montreal had a very modest beginning. Towards 1800 the water from springs was diverted from Mount Royal and distributed through some of the streets of the city in wooden pipes. In 1815 this precarious supply was replaced by a system of distribution of water pumped from the river and raised into tanks containing 240 000 Imperial gallons.* In 1845 the city bought this system from a private company, after which an epoch of progress was begun by the construction of a reservoir containing 3 000 000 Imperial gallons and situated at that time outside of the city at a place called "Côte à Baron." This reservoir, now abandoned, has been turned into an ornamental fountain in one of the squares of the city (St. Louis Square).

The time had now arrived when the intake from the river, in the middle of the harbor, and consequently exposed to all sorts of pollutions, could no longer be used with hygienic safety to supply a city full of future promise and anxious for the health of its inhabitants. As early as 1847 it had been proposed to take water at the Lachine Rapids, above the city, and to make use of the power of these rapids to raise the water, but this scheme, and others similar, were not seriously considered until 1853, when the city council concluded to confer upon Mr. T. C. Keefer, civil engineer, the duty of preparing plans for an aqueduct capable of supplying 5 000 000 Imperial gallons daily. The study of this project, its examination by consulting engineers, etc., postponed the beginning of its construction to the year 1853, and its termination to the year 1854.

The system then established included an open canal $4\frac{3}{4}$ miles long, having its entrance about one mile above the Lachine Rapids, at an elevation of 37 feet above the level of the harbor of Montreal. The dimensions of the canal were 40 feet wide at the water surface and 8 feet deep. This canal, throughout most of its course, is actually used to supply the city at present.

At the time of its construction this canal supplied more than sufficient water to develop 300 horse power, and to raise 200 feet above the level of the water in the harbor 5 000 000 Imperial gallons of water, being at the rate of 40 Imperial gallons per capita for a population double what it was then (60 000). At the end of that canal were situated the settling basin and the wheel house,

* 1 Imperial gallon = 1.2 United States gallons (approx.).

about as they stand to-day. The hydraulic motive power was utilized by two breast wheels working six pumps to raise the water to a reservoir situated on the slope of Mount Royal along McTavish Street, forming the present low level reservoir, which is but an enlargement of the original one. That reservoir had then a capacity of 15 000 000 Imperial gallons.

The whole of this system had been well devised for the quality and quantity of water necessary for a limited future, sufficient in fact for a population double what it was then; but the rapid increase of population, which has nearly quintupled since, and the inconveniences produced by the severity of our winters on the wheels, have necessarily obliged the authorities of the water works to substitute turbines for breast wheels, and also to construct an auxiliary steam plant, with a view to replacing hydraulic power during the times of low water in summer, and during the winter on account of ice, frasil, etc. The steam plant was also found to be necessary to provide for the insufficiency of the water power, when the consumption of water by the city exceeded that for which provision had been made when the canal was constructed.

The author having mentioned a few moments ago the serious difficulties due to the severity of the winters, when ice is formed in the aqueduct and paralyzes the work of the hydraulic wheels, he believes that the best way to illustrate these difficulties would be to present to the audience a few cross-sections of said aqueduct made in 1866, during the month of March (Fig. 1). These sections show that the amount of ice formed results in a decrease in the supply of water furnished by the aqueduct, and explain the temporary incapacity of the hydraulic plant. These are the chief difficulties which have been encountered from 1856 to the present time, and it was owing to them that the authorities of the water works changed the breast wheels for turbines and made successive additions of steam pumps, until the present plant at the low level station, which will be explained further, was erected as it stands now.

Meanwhile the population of the city was increasing, and was extending itself upon the heights situated east of Mount Royal, at an altitude too great to be supplied by the system whose summit was at the McTavish Reservoir.

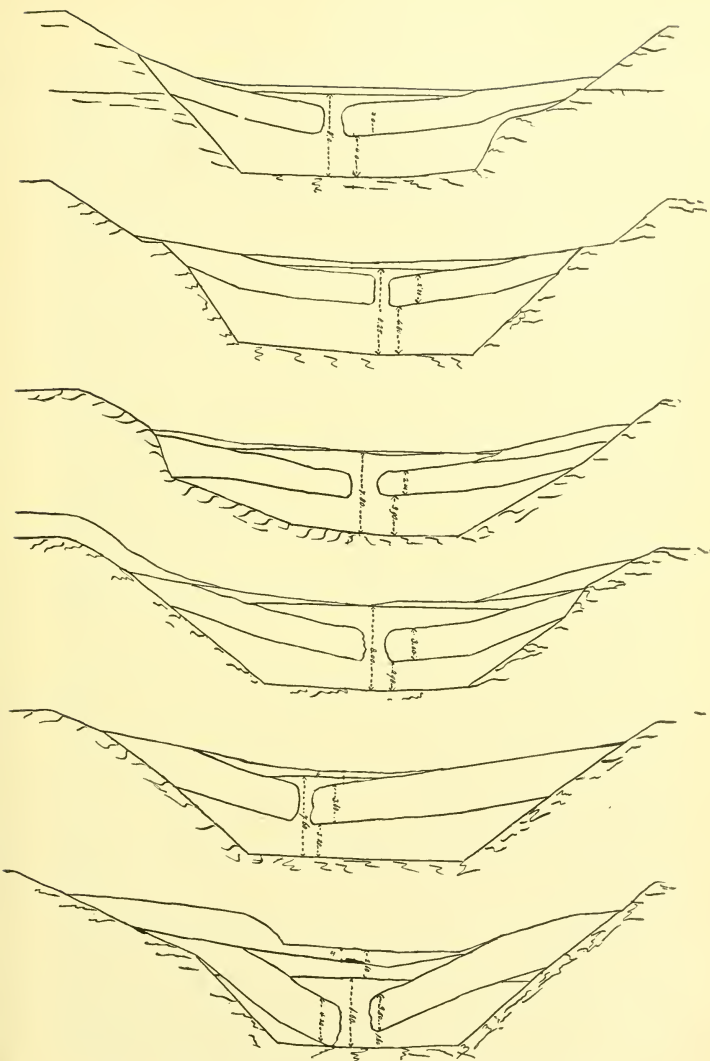


FIG. 1.—SECTIONS OF AQUEDUCT SHOWING FORMATION OF ICE.

This state of things necessitated the establishment of the present high level system, that is, the construction of the reservoir at mid-way on the mountain slope, and of a pumping station to carry the water from the low level system to the high level distributing service, to a height of 422 feet above the level of water in the harbor. A Worthington steam pump, with a daily capacity of 500 000 Imperial gallons, was then sufficient to supply the high level system.

As the changes were being made to the low level machinery, as mentioned above, several schemes were prepared to put the aqueduct in condition to supply the wants of the rapidly increasing population without necessitating the resort to the expensive use of steam. All of these schemes had in view one of two objects : the increase of water power or the substitution of a gravity supply. Montreal is not advantageously situated to make use of this latter scheme. Built upon an island, bordered on one side by the St. Lawrence River, — whose width precludes any idea of viaduct or syphon to bring water supply on this side, — on the other side it is bordered by a branch of the Ottawa River and adjacent to another island, formed by the same river dividing itself into two branches, not so wide as the St. Lawrence River, but of sufficient width to make the bringing across of a gravity aqueduct very expensive.

To avoid these financial difficulties, nothing was left but to find north of the city a water supply taken at a sufficient altitude (that is, more than 425 feet above the St. Lawrence), adequate to the present and future wants of the city. The ridge of the Laurentian Mountains, whose first summit is situated more than 30 miles from Montreal, was the only spot where such a water supply could be found. Surveys and levels were made, and established the fact that a water supply could be taken from Lake Ouareau, situated at an altitude of 450 feet and at a distance of about 60 miles from Montreal, but the estimated cost of such an undertaking prevented the further study of it. Consideration of the gravity plan was consequently superseded by the study of a sufficient hydraulic power system. While on this question the author would like to add that it is his opinion that the scheme of carrying water from the Laurentian Lakes would result in difficulties other than the supposed heavy cost. The water would be sure to be contaminated

in a country where the watershed supplying the lakes is entirely covered with forests, where timber cutting on a large scale is constantly going on, employing a large number of men and horses; and numbers of the creeks run nearly dry in summer and would only supply at the chosen locality impure waters. These and many other considerations were the causes which led to preference being given to the plan of the superintendent then in charge of the water works, Mr. Louis Lesage. This scheme was simply to carry the entrance of the aqueduct 3 000 feet up the river and to make it 130 feet wide at the water surface, 78 feet wide at bottom, and 14 feet deep.

These dimensions would provide sufficient power to supply 30 000 000 Imperial gallons. In 1877 the construction of works on this plan was begun, the new entrance of the aqueduct was made, and the aqueduct was dug 130 feet wide for 4 800 feet in length, as it stands to-day. The cost of the work prevented its continuation, and this accounts for the periodical growth of the steam plant.

However, this beginning of enlargement had a favorable effect on the water in the aqueduct and the formation of ice, in such a way as to better protect the efficiency of the hydraulic pumps.

In 1878, the low level reservoir (McTavish) having become insufficient, it was enlarged so as to bring its capacity to 37 000 000 Imperial gallons. In 1889 the population fed by the high level system had increased so much that a new steam pump, of 2 500-000 Imperial gallons' capacity had to be provided for this district. This increase in the population is still going on, and the necessity of ensuring its supply against any uncertainty led the author to have the city council provide for the installation of a pump operated by electric power, which pump, of a capacity of 5 000 000 Imperial gallons, is at present in process of erection. When it is in operation the old steam plant will be kept as a duplicate in case of emergency.

The successive changes which the author has attempted to explain to his best ability have placed the Montreal Water Works in a position to provide a daily average water supply of about 24 000 000 Imperial gallons, which is sufficient for the present population.

The question of increasing the motive power will again shortly

present itself, and the competition of schemes similar to those already spoken of will be open again, together with a scheme of water filtering, because although the water taken in the river is generally wholesome, the spring-time has always a bad effect upon the waters, this being caused by the snow melting and the discharge into the river of the drainage of the lands along its banks. This inconvenience, although temporary, has led the public to wish to see a water filtering system adopted, and the municipal authorities will have to deal shortly with this question.

DESCRIPTION OF THE WATER WORKS.

Aqueduct. — As already stated, the present source of water supply for the city is the St. Lawrence River, from which the aqueduct has its entrance $1\frac{1}{2}$ miles above Lachine Rapids, 38 feet above the level of water in the harbor.

The present aqueduct, from the entrance to the junction of the old aqueduct, has a mean width of 140 feet and a depth of 14 feet, for 4 800 feet; it is then continued by the old aqueduct, which has a mean width of 30 feet, a depth of 8 feet, and is 26 200 feet long. The fall is 5 inches per mile.

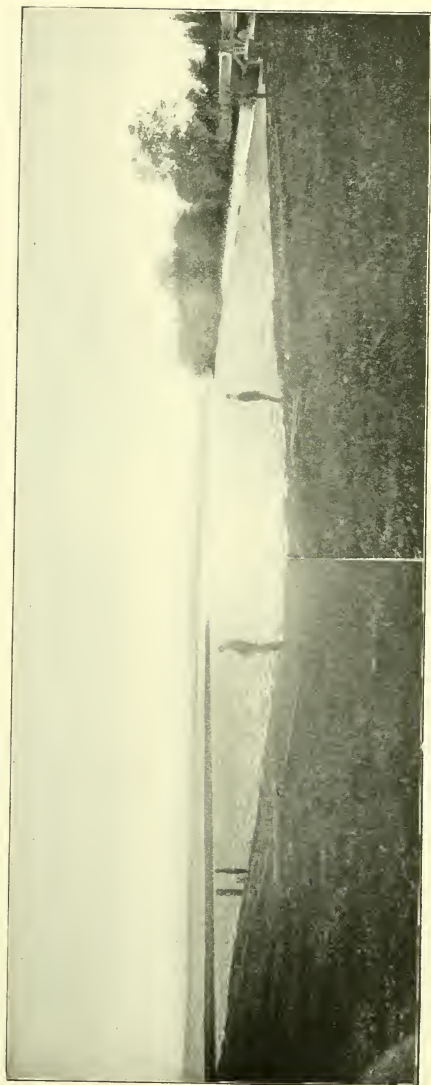
The aqueduct ends at a settling basin of a capacity of 1 064 885 cubic feet, used for the distribution of the motive power to the hydraulic engines and for the drawing of the water supplying the city.

At the mouth of the aqueduct a pier about 1 000 feet long has been built for the purpose of slackening the current of the river. Sluice-gates, situated at the mouth, and 2 dams with movable gates, situated in the canal, regulate the level of the water; 18 bridges cross the canal and afford the means of circulating on the roads which connect the several portions of the riverside properties.

Low level pumping station. — The water is raised by means of two systems — by hydraulic machines to the extent of about 60 per cent. of the consumption and by steam engines for the balance.

The total quantity of water raised by the pumping apparatus of that station during the last fiscal year was 8 167 734 489 Imperial gallons.

There are several buildings connected with the low level pumping station, of which these are three principal ones, — the first



STILL WATER BASIN. — ENTRANCE OF AQUEDUCT.



FIG. 1. — ENTRANCE OF AQUEDUCT, ST. LAWRENCE RIVER.



FIG. 2. — STILL WATER BASIN AT ENTRANCE OF AQUEDUCT.



FIG. 1.—NEW AQUEDUCT AT JUNCTION WITH THE OLD.



FIG. 2.—ROAD BRIDGE AT ENTRANCE OF OLD AQUEDUCT.



FIG. 1. — AQUEDUCT NEAR SETTLING BASIN.



FIG. 2. — LOW LEVEL PUMPING STATION AND SETTLING BASIN.



FIG. 1. — LOW LEVEL PUMPING STATION ENGINE HOUSE.



FIG. 2. — LOW LEVEL PUMPING STATION AND TAILRACE.



FIG. 1. — MCTAVISH STREET RESERVOIR — NORTH END VIEW.



FIG. 2. — MCTAVISH STREET RESERVOIR — SOUTH END VIEW.

contains the turbines, operated by the aqueduct water itself, and 4 sets of pumps, namely:

No. 1. — A Jonval turbine, with 2 double-acting pumps, which can pump 4 000 000 Imperial gallons per 24 hours.

Diameter of the wheel	8 feet.
" " pumps	1 foot 6 inches.
Stroke	6 feet.

No. 2. — A "Samson" horizontal double wheel, with 2 double-acting pumps and an air reservoir, which can pump 5 000-000 Imperial gallons per 24 hours.

Diameter of the wheel	40 inches.
Width " "	20 "
Diameter of the pumps.....	23 "
" " plunger-piston	20 "
Length of stroke.....	36 "
Interior diameter of the air reservoir	30 "

No. 3. — A "Jonval" turbine, with 3 double-acting pumps and 2 air reservoirs, which can pump 3 000 000 Imperial gallons per 24 hours.

Diameter of the wheel	6 feet.
" " pump.....	1 foot 8 inches.
Length of stroke.....	4 feet.
Interior diameter of the air reservoirs	6 " 6 inches.

No. 4. — A "Jonval" turbine, with 2 double-acting pumps and an air reservoir; capacity, 3 000 000 Imperial gallons per 24 hours.

The overflow of the settling basin and the water operating the hydraulic machines falls into a waste channel, below the building, and after a course of about 3 500 feet, flows into the St. Lawrence River, opposite the downstream point of the Nuns' Island.

The second building contains the steam-engines, comprising 3 sets of pumps, namely:

No. 1.—A high-duty Worthington engine of a capacity of 10 000-000 Imperial gallons per 24 hours.

Diameter of the high-pressure cylinder	28 $\frac{3}{4}$ inches.
" " low " "	57 $\frac{1}{2}$ "
" " plunger-piston.....	31 $\frac{1}{2}$ "
Stroke	48 "
Interior diameter of the air reservoir	39 $\frac{1}{4}$ "

No. 2. — A high duty Worthington engine of a capacity of 10 000 000 Imperial gallons per 24 hours.

Diameter of the high-pressure cylinder	25 inches.
" " low " " 	40 "
" " plunger-piston	27 $\frac{1}{8}$ "
Stroke	38 "
Interior diameter of the feeding cylinder	35 $\frac{1}{2}$ "
" " " air reservoir	23 $\frac{1}{2}$ "

No. 3. — A high duty Worthington engine (duplex) of a capacity of 8 000 000 Imperial gallons per 24 hours.

Diameter of the high-pressure cylinder	33 $\frac{3}{4}$ inches.
" " low " " 	58 $\frac{1}{2}$ "
" " pumps	37 $\frac{1}{4}$ "
" " plunger-piston	29 "
Stroke	48 "
Interior diameter of the air reservoir	39 $\frac{1}{2}$ "

The third building contains the steam generators, which consist of 2 batteries of 3 Heine boilers each, and a battery of 3 Lancashire boilers.

The other buildings are used as sheds for the storage of coal and supplies, machine shops, and employees' dwellings.

From the pumping station the water is forced into the low level reservoir and into the pipes through two mains of 30 inches diameter, having together a length of 16 102 feet, and through two 24-inch mains having a total length of 27 709 feet.

One of the 30-inch mains is still unfinished and only branched upon the other of the same diameter, after their passage under the Lachine Canal.

The other 30-inch main does not extend as far as the reservoir; at the intersection of McGill College Avenue and Sherbrooke Street it is connected with the two 24-inch mains, which alone go as far as the reservoir; from that point, the said 30-inch main extends on Sherbrooke Street as far as Delorimier Avenue, near the eastern limits of the city.

Low level reservoir.—The pumps at the low level station raise the water up to the main reservoir of the city, situated at the angle of McTavish Street and Carleton Road, at the altitude of 204 feet above the river and 165 feet above the intake basin of the low level pumping station.

The said reservoir, dug into the rock, has its bottom on the uneven bed of the excavation, and its perimeter walls are partly formed by the sides of the excavation, the rest of the walls being composed of undressed stone masonry pointed with cement.

It is divided into two equal parts by a masonry wall of the same character as the perimeter walls.

The capacity is 37 000 000 Imperial gallons of water.

A building attached to said reservoir contains the valves and sluice-gates regulating the distribution and the reserve of water for the section of the city supplied by the low pressure; said section comprising all that part of the city extending from the St. Lawrence River to the following limits (northwards): Sherbrooke, University, Prince-Arthur, Durocher, Pine Avenue, St. Lawrence, Duluth, Cadieux, and Mount Royal streets.

High level pumping station. — A building erected on the land adjoining the above-mentioned reservoir contains the high level pumping machines, which consist of 2 pumps operated by steam.

1. A high pressure Worthington pump (duplex) of 24 horse-power and of a capacity of 500 000 Imperial gallons per 24 hours. (This pump is almost unfit for use.)

2. A high pressure Gilbert pump (compound system) of 250 horse-power and of a capacity of 2 500 000 Imperial gallons per 24 hours.

The steam is supplied by a sectional tubular boiler of the Caldwell high pressure type, 200 horse-power, fed by 2 American mechanical stokers.

Old boilers of the locomotive type of 120 horse-power each are still used during the cleaning, or when accidents take place to the Caldwell boiler.

The pumps take the water from the low level reservoir and raise the same by a force main of 20 inches and 12 inches diameter and 1 674 feet long, passing through McTavish Street, Pine Avenue, Mt. Royal Park, and ending at the high level reservoir, situated on the slope of the mountain, opposite Peel Street, at the altitude of 434 feet above the river and 230 feet above the low level reservoir.

As above mentioned, a new 5 000 000 Imperial gallon electric pump is in course of erection at this pumping station. It will replace the very old steam plant, which will be completely overhauled and will be kept in good order in case of emergency.

High level reservoir. — This reservoir is built about in the same way as the low level reservoir. It is composed of only one compartment.

Its capacity is 1 750 000 Imperial gallons; it equalizes the water supply, and contains the reserve for the section of the city supplied by the high pressure.

The district so supplied comprises all that part of the city lying north of the limits above mentioned for the low pressure.

Distribution system. — In addition to the force mains raising the water into the reservoirs, the distribution system of the city is composed of :

28 509 feet cast-iron mains of 30 inches diameter.						
66 198	„	„	„	24	„	„
13 040	„	„	„	20	„	„
17 493	„	„	„	16	„	„
237 887	„	„	„	12	„	„
122 179	„	„	„	10	„	„
123 873	„	„	„	8	„	„
256 714	„	„	„	6	„	„
329 990	„	„	„	4	„	„
2 239	„	„	„	3	„	„
518	„	„	„	2	„	„
625	„	„	„	1½	„	„

Total 1 119 274 feet or 212 miles.

A map of the distribution system is shown in Fig. 2.

The distribution of water by these mains is regulated by means of 3 082 valves of various diameters.

These mains supply 1 772 public hydrants and 58 private ones.

They are all laid underground, in cut, with the exception of a portion of the 24-inch force mains, which are contained in an underground gallery for a distance of about 120 feet, from the Carleton Road crossing to the low level reservoir.

The water is distributed to the ordinary consumers by free cocks and to manufacturers, etc., by meter.

In order to complete the description of the system, I will mention the central shops and stores, situated at the corner of St. Charles Borromée and Lagauchetière streets, in the center of the city, and the secondary shops on Cadieux, Grand Trunk, and Desery streets, which provide for the wants of the service in the distant wards.

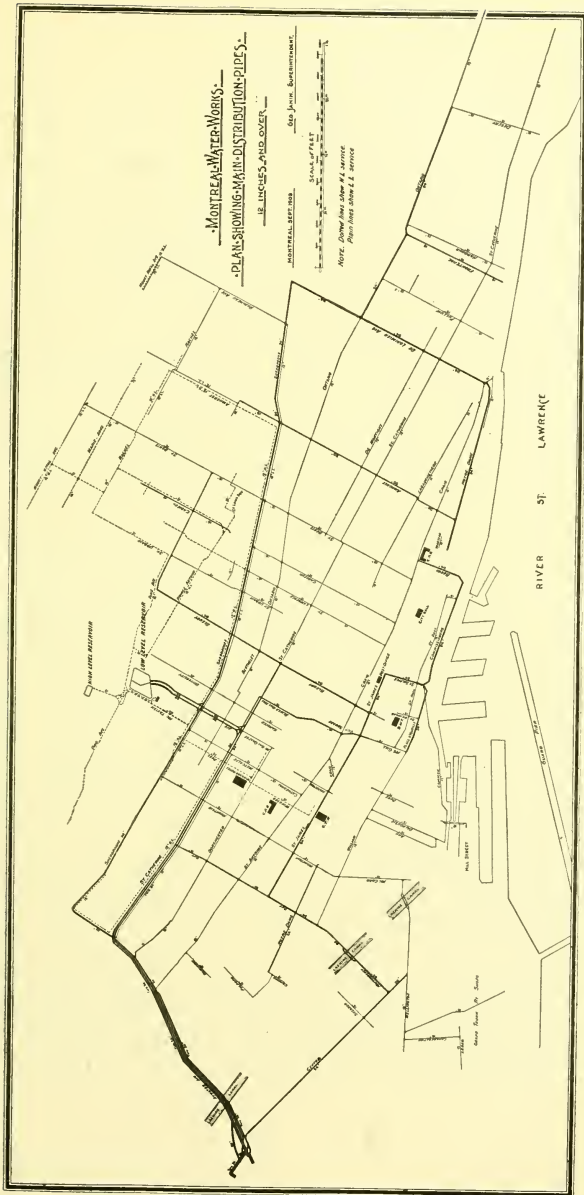


FIG. 2.

SERVICE BOXES OF THE MONTREAL WATER WORKS.

BY T. W. LESAGE, ASSISTANT SUPERINTENDENT,
MONTREAL WATER WORKS.

[*Read September 9, 1903.*]

In Montreal the water rates are not on the property, but they are a direct tax on the tenants or householders, who pay according to the assessed rental of the premises occupied.

The only means of ensuring payment of these rates by the city is to control the supply by a stopcock on the water service pipe at the sidewalk line. Thus each tenant ratepayer has to be provided with a separate stopcock and box.

An ordinary two or three-storied house in the most populous section of the city will often contain from four to six or eight tenements respectively, and will require that number of separate service cocks and boxes in the sidewalk. Besides the great number of service boxes called for by this disposition of the water rates, there is also the severity of the climate to be contended with. The frost line in winter is generally at a depth of four feet or more, and in certain soils or localities it reaches a depth of over six feet. The service cocks are generally laid at sufficient depth to be free from frost, but the box itself in the upper parts is always subject to the upheavals and disturbances caused by it. Thus it may be seen that the question of efficiency at all times of these service boxes is one of importance in the department.

There have been many attempts made to improve or simplify the service in that respect, and a number of styles have been used and changes made in service cocks and boxes to meet all conditions.

The simplest and most ready-to-hand box is the wooden service box. It was early adopted in Montreal. It is made of four pieces of two-inch plank nailed together, the inside measurements being four inches square at the bottom by about two inches square at the top, and six feet long.

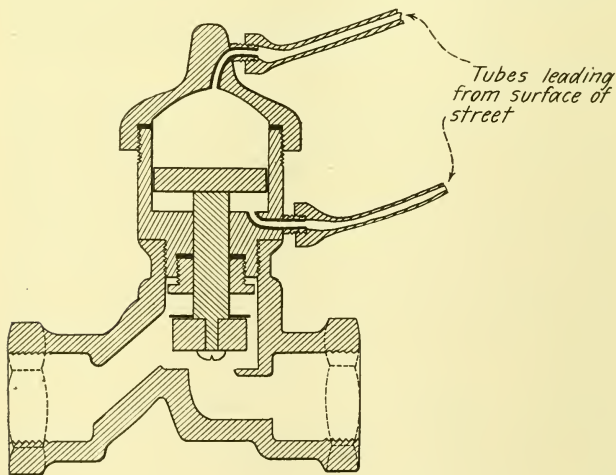
This primitive box was soon found troublesome from the effect of frost, especially in clayey soils. The heaving from this cause made it inoperative as a guide to the stopcock, and caused numerous accidents by its projecting above the sidewalk level. It was always next to useless after several years, and had to be dug up in order to get at the cock.

About twenty-five years ago the city adopted the first tubular iron service box with rod. This box was a one-inch wrought-iron tube fitted to a cast-iron bottom piece with projecting flange, allowing of telescopic action. (See Plate I.) It contained a fixed rod pinned to the stopcock and extending up through the tube to permit of working the cock from near the surface of the street. It was an improvement on the old wooden box, due to the telescopic action of the upper tube in the bottom piece. It soon proved defective from the rapid rusting and clogging of the rod in the narrow tube. The telescopic arrangement, consisting of a vertical groove in the cast-iron base, was also subject to rapid corrosion.

The next improvement in the city was the pneumatic stopcock, shown in cross-section by Fig. 1. This was an attempt to do away with the service box altogether by an improved style of service cock. Its mechanism consists of a vertical piston acted on by compressed air; the lower end of the piston rod having a rubber valve, by its up-and-down motion serves to open or close the water passages of the cock. The cock is worked from the surface of the street through one-eighth-inch brass tubes with a pump such as bicyclists use. This pneumatic cock was expected to do away altogether with the service box and all its disadvantages. Theoretically, it appeared to be the solution of the difficulty. However, a few years' experience showed several defects in its practical operation. The brass tubes, owing in most cases to defective setting, were acted upon considerably by frost. They split and became leaky and inoperative. Then again, a sudden shutting of the main pipe on the street, and the consequent partial vacuum in the pipes, caused the unusually sensitive air pistons to fall by their own weight and thus close the cocks. The crooked water passageway of the cock in use was also liable to silt up more rapidly than the ordinary straight-way cock. It was generally felt that the mechanical disposition

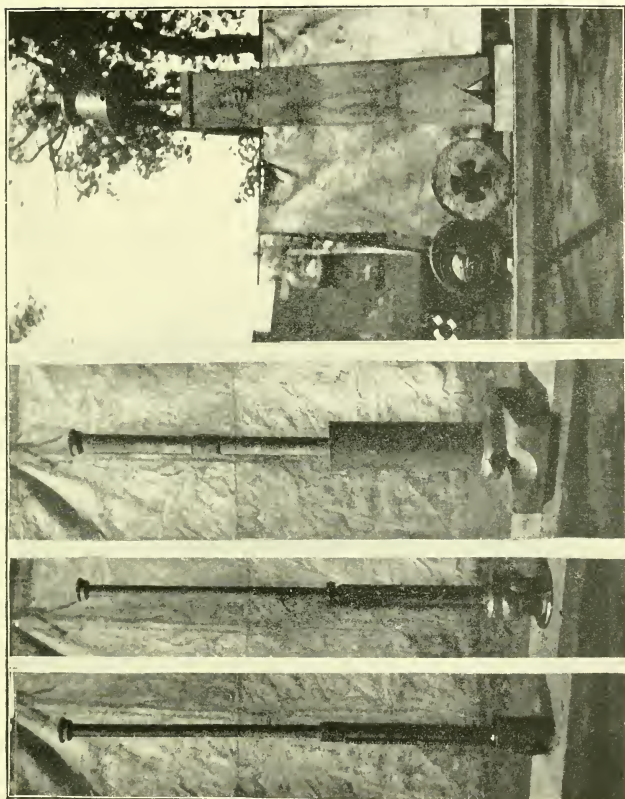
and arrangement of the pneumatic cock, with its working tubes, required too fine setting and adjustment, and was unsuited to the rough-and-ready manipulation of the ordinary laborer.

Another tubular iron box was introduced consisting of inch and a quarter or inch and a half galvanized-iron pipe, fitting with a telescopic sleeve joint into a bottom piece made of vitrified clay. (See Plate I.) The top piece or sidewalk plate is a neat brass cap with screw threads fitted to a brass nipple on the end of the galvanized pipe. The first cost of this box is high, and its maintenance somewhat expensive. The threaded nipple and brass sidewalk caps were the chief source of trouble, as there appears to be galvanic action set up in the contact of brass and galvanized iron, which soon causes the screw threads on the iron pipe to corrode and the brass caps to fall off. Then



Montreal Water Works
~PNEUMATIC SERVICE COCK~

FIG. 1.



SERVICE BOXES, MONTREAL WATER WORKS.

again the brass caps and nipples are valuable as scrap. They are easily removed and converted by the unscrupulous to the junk shop, thus requiring constant renewals by the department.

The present service box as it is being laid to-day consists of an inch and a quarter or inch and a half ordinary tarred iron pipe about 4 feet long, fitting with a telescopic service joint into a bottom piece of wood or vitrified clay, about 2 or 3 feet long. Two slits are made in the upper end of the iron pipe about 2 inches lengthwise, and the ends are turned back or splayed at right angles to form a projection to fit in the cast-iron base of the sidewalk plate. (See Plate I.) This sidewalk plate or casing is of cast-iron, cylindrical in form, about 6 inches deep by 4 inches wide. When set in the concrete of the sidewalk pavement it is perfectly rigid and the inside tube has several inches vertical play inside but cannot disturb the surface of the pavement. The service cocks are fitted with $\frac{5}{8}$ -inch rods carried up to within 2 feet of the sidewalk level. The box complete, comprising rod, tube, bottom piece of wood and deep cast-iron sidewalk casing, costs about \$1.90. The deep cast-iron sidewalk casing in itself weighs 23 pounds and costs 69 cents. The cast-iron removable cover is of the pattern of one long in use in the department and therefore interchangeable with the old covers in all parts of the city. Though bulky enough to be not easily lost sight of, it is not of sufficient intrinsic value as scrap iron to become an object of much trading among second-hand dealers. This box combines simplicity and cheapness and has all the advantages of more pretentious and expensive arrangements for the same purpose. It will escape the inevitable decay of time and weather in exposed situations about as long as any. It has one valued improvement by the fact that the tube or box itself can no longer be worked up by frost above the sidewalk level, thereby doing away with a fruitful source of accidents and damages against the city.

THE LAWRENCE FILTER.

BY M. F. COLLINS, SUPERINTENDENT LAWRENCE WATER WORKS.

[Read September 10, 1903.]

I have been requested by your President to bring before you, in a short talk about the Lawrence filter, the method of its operation and certain features of the results. Rather than bore you by a long paper, I have thought it best to show slides of the filter and its operation, and say a few words about each as it appears.

The Lawrence filter (see Fig. 1, plan of filter) was built in 1892-93 after designs and under the direction of Hiram F. Mills, C.E., member of the Massachusetts State Board of Health and citizen of Lawrence at that time. Its original cost was \$65 000.00. The additions and improvements in subsequent years have raised the total cost to about \$80 000.00. The filter is supplied with water from the Merrimac River by gravity, and the filter drains into an old filter gallery or brick conduit along the north side, which empties into the pump well.

The unique feature of the filter is that it has an undulating surface, divided into parts by concrete troughs, over which the water flows gradually as the filter is being filled when started in operation. This design was caused by the plan for intermittent operation, which was deemed necessary in order to thoroughly mingle air with the water for better purification. In addition, the size of the sand directly over and for five feet each side of the underdrains was finer than that in the intermediate section (size, 0.25 mm. to 0.30 mm). However, the need of intermittent filtration has not been apparent, and, as the demand for water has been constant and large, the filter has been for some time operated in a continuous manner, that is, without periods of rest each day for the purpose of allowing air to penetrate into the sand. Also, as sand has been scraped from the surface from time to time and replaced each year, it has come to pass that the distribution of sizes in different sections is no longer maintained and all of the sand is about the same size.

SCRAPING.

When it becomes necessary to scrape a section of the filter the inlet to that section is shut off the night before, and if water is not

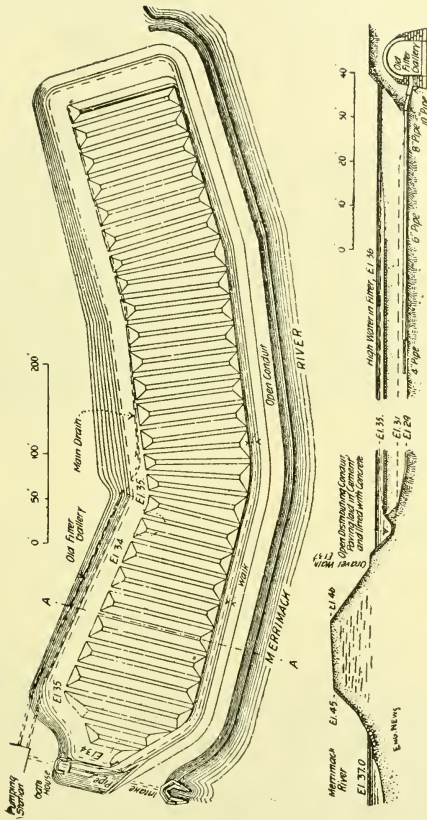


FIG. 1.—THE LAWRENCE FILTER, AS ORIGINALLY DESIGNED.

going through the sand fast enough to have the surface clear by morning, the 8-inch centrifugal pump which was put in for the purpose of draining the bed is started and the surface water pumped back into the river. Thus the section is ready to work upon at the usual time of beginning work in the morning. The

surface sand is then removed, from one-half to one inch in depth. This is thrown into small piles about ten feet apart on the surface of the bed, then wheeled to a temporary dump on the lower roadway.

Plate I, Fig. 1, shows the operation of scraping in progress.

SANDING.

In the successive scrapings of the surface of the filter bed during the year a total of about ten or twelve inches in depth of the sand is removed. All of this is replaced at one time in the following manner: The surface of the filter bed between two surface conduits is first scraped and the scrapings removed; then a section along the distributing channel about five feet wide is spaded or loosened up, and from the adjoining section, five feet wide, sufficient sand is thrown up over the first section, adjoining the distributing channel, to bring it to proper grade. New sand is then brought in to fill the lower half of the excavation thus made, and from the next adjoining five feet wide sufficient old sand is taken to cover the new and bring that section to grade, and so on continuing the operation over the whole surface of the filter, working from the line of the distributing channel toward the opposite side of the bed, the object being to cover the new sand with five or six inches of the old sand, and keep the surface of the filter bed always of the old sand.

WASHING SAND.

Plate I, Fig. 2, shows the sand-washing machine. The bowls of the machine are four in number, and sand drops to the bottom of each bowl and is caught by an inflowing horizontal jet and carried across and upward through a 3-inch pipe into the next bowl. This is continued until it passes through the four bowls and then to the sand boxes.

The process of washing sand from the lower roadway has been in operation for two months and gives as good results, both as to the amount of sand washed and the removal of river silt and organic matter, as the washing machine on the upper permanent dump.

This method does away during the summer months with the necessity of hauling the sand by teams from the lower roadway to the upper washing machine, which means a considerable saving in



FIG. 1. — SCRAPING THE SURFACE OF THE BEDS.

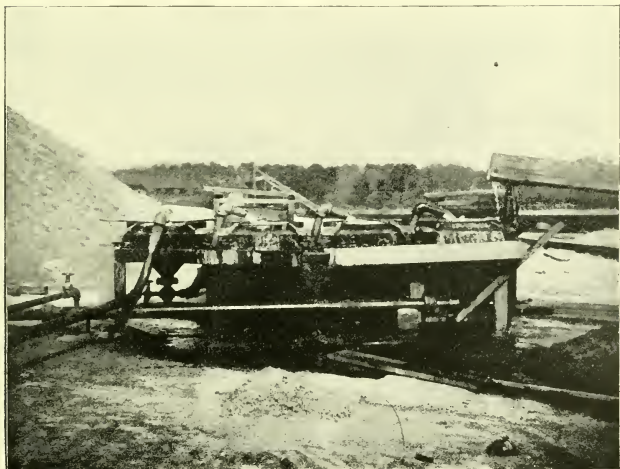


FIG. 2. — SAND WASHER.



FIG. 1.—REMOVING ICE FROM THE-FILTER.



FIG. 2.—NEW ICE RUN.

team hire. Under the present system the sand is brought to the washer by a scraper with a horse attached, calling for a driver and one man to handle the scraper. Under the old method four single carts and six men were required to convey the unwashed sand to the washing apparatus.

ICE.

During the months of December, January, February, and March, scraping can seldom be accomplished without first removing ice from the surface of the filter. In order to scrape a section of the filter at such a time, the ice, together with any snow which may be upon it, must first be removed, usually on the day before scraping. In cold weather an additional coating of ice, sometimes one inch or more in thickness, forms before the filter is entirely drained, causing an increased cost and delay in scraping.

On December 1, 1901, ice on the filter was four inches in thickness, and on December 8, 1901, it was twelve and one-half inches in thickness.

Plate II, Fig. 1, shows the process of removing ice from the filter. Plate II, Fig. 2, shows an ice-run that was put in two years ago, and also the old machine in the distance. The old machine carried an 18-inch by 30-inch cake, this one carries a cake 36 inches square. It is attached to the old machine and is run by a belt. The delivery is so high that we are enabled to cut all day without moving; with the old machine it was necessary to move three or four times daily.

DIVISION WALLS.

The filter was originally built in one unit of an area of two and one-half acres, so that when any portion needed scraping it was necessary to draw the water from the entire filter and put it temporarily out of service. In 1902 the water board authorized the building of two division walls, dividing the filter into three parts. As the filter is at present, when one section is out of service, whether for the purpose of scraping or sanding, the pumps are kept running, and the only loss in addition to the lessened quantity of water filtered is a decreased duty of the pumping engine.

Plate III shows a part of the westerly section of the filter, show-

ing gate house, together with the exposed surface drainage pipe and the connection of the 30-inch main supply pipe with the old open distributing channel.

Plate IV shows the westerly division wall, with the 16-inch supply gate, also the 8-inch gate to be used for pumping from beds.

Plate V illustrates the easterly wall and gate chamber, showing water on the easterly section and the water being let on the middle section of the filter.

Plate VI is a general view of the filter as it is to-day, and shows the two walls, with the water on the easterly section, the water being let on the middle section, and the westerly section being scraped.

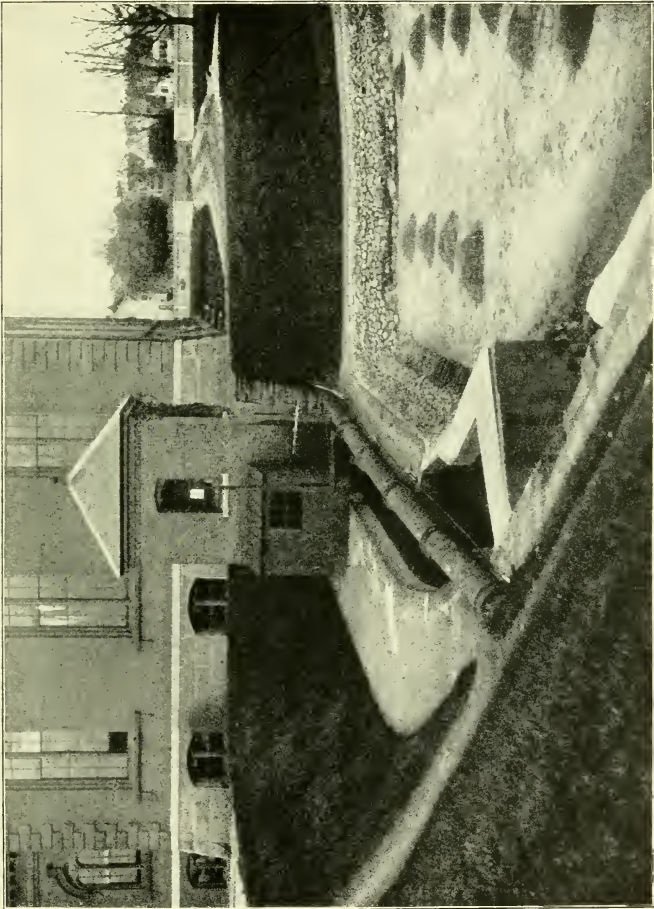
I know of no better description of the division walls than the following, furnished by Mr. A. D. Marble, city engineer, for the president of the water board:

"To prevent the freezing of the whole filter bed in winter while a portion was being cleaned, as well as to allow two-thirds of the bed to be in use at all times during the entire year, two walls were constructed last season across the bed, dividing the filtering area into three nearly equal parts.

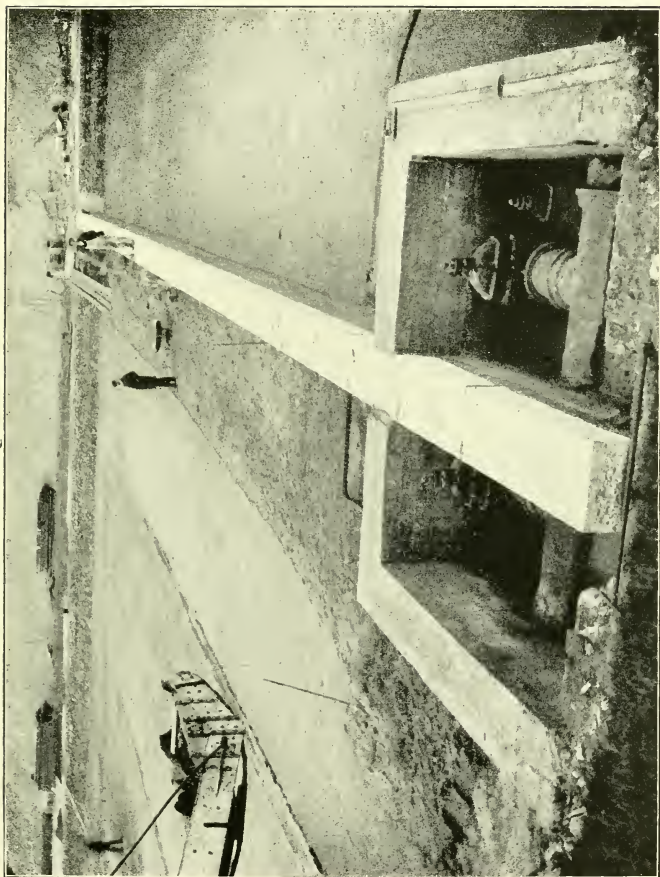
"A large iron pipe ranging from 30 inches to 16 inches in diameter was laid along the river side of the bed in the old conduit and connected with the gate chamber, which supplies the bed with water from the river. This pipe feeds the different sections with the river water through 16-inch valves.

"In the old conduit is also laid an 8-inch iron pipe which is connected with a pump and assists in removing the water from the surface of the bed when preparing to clean it. This drain pipe also has valves connecting with each section of the bed.

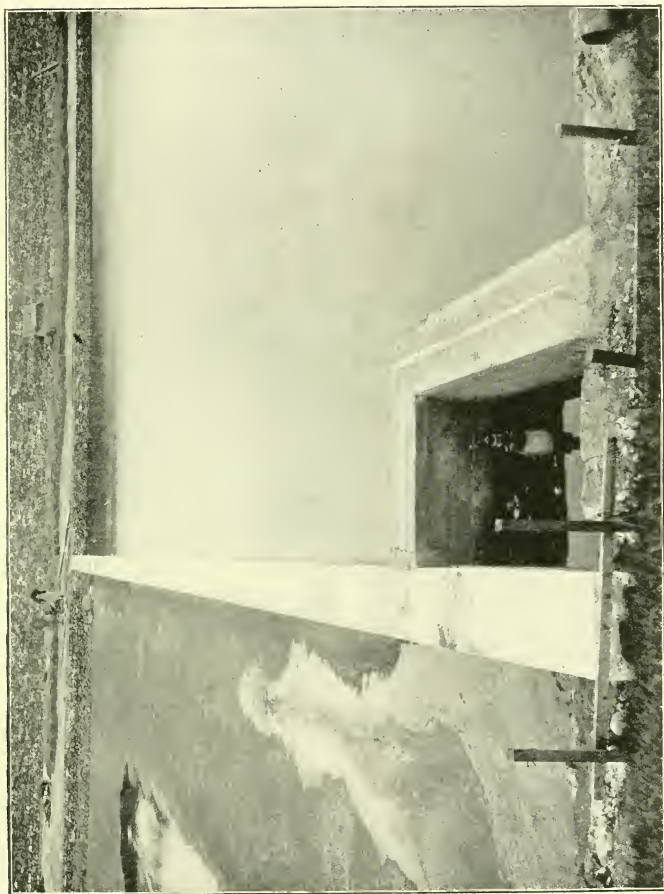
"The concrete was mixed in the following proportions: One part of Atlas Portland cement, three parts sand, and five parts clean screened gravel. The top of the walls is at elevation 38, and on a level with the driveway and the walk around the bed. The bottom of the foundation is at elevation 30.75 (about), or about 1 foot 9 inches above the bottom of the underdrains. They were built as nearly as possible along the summit of the ridges in the bottom of the bed, and about 15 feet distant from the underdrains that convey the filtered water to the pump well. Being located so far



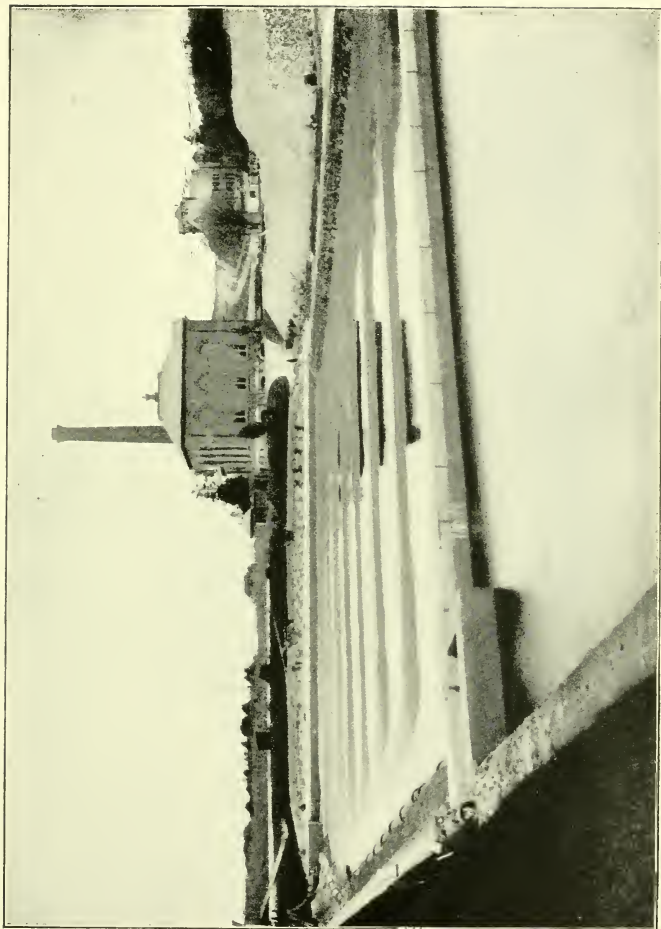
WESTERLY SECTION OF FILTER, GATE HOUSE, EXPOSED SURFACE DRAINAGE PIPE AND CONNECTION OF
30" MAIN SUPPLY PIPE WITH OPEN DISTRIBUTING CHANNEL.



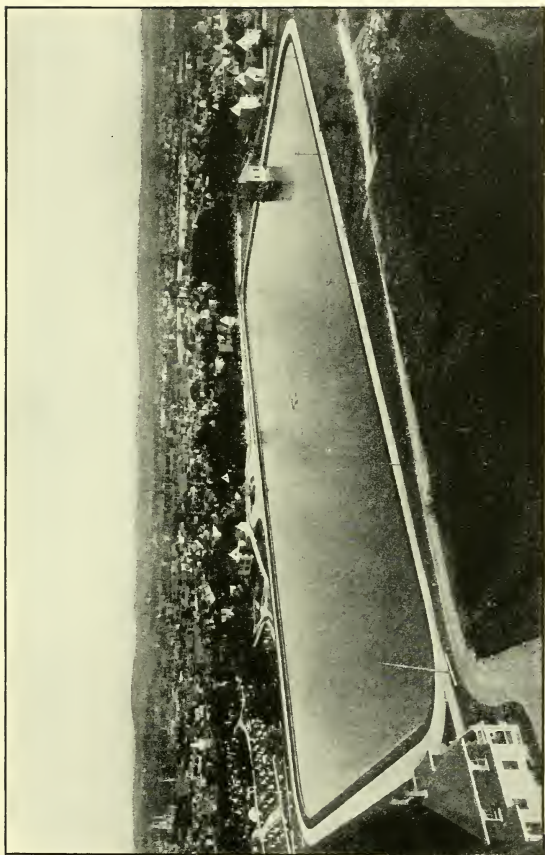
WESTERLY DIVISION WALL AND GATE CHAMBERS.



EASTERLY DIVISION WALL AND GATE CHAMBER.



THE LAWRENCE FILTER, WITH DIVISION WALLS.



THE LAWRENCE RESERVOIR, FROM TOP OF HIGH-SERVICE TOWER, LOOKING EAST.

from these underdrains, the danger of unfiltered water reaching the pump well from the disturbance of the bed was reduced to a minimum.

"The foundation section of the walls is of three different thicknesses, stepping up from 4 feet in thickness at the bottom to 2 feet 8 inches in thickness just below the surface of the bed. Each step in the concrete has a rise of 9 inches and a tread of 4 inches, and makes an indirect course for the water down the sides of the foundation, and gives a bond for the sand filling.

"The exposed section of the wall above the surface of the bed is 2 feet thick, capped with a pointed granite flagging 1 foot thick and of a width just equal to the thickness of the wall. The top edge of this flagging is rounded, leaving no sharp edges to be broken off in the process of cleaning the bed of ice.

"The concrete walls run into the embankment at either end sufficiently to prevent the water leaking around them from one bed into the adjoining bed.

"The valves on the feed pipe are located in small concrete chambers built close to the walls in one corner of the different sections.

"A concrete apron outside the gate chamber receives the first wash of the water in refilling the bed from the river, and prevents the surface of the bed from being disturbed.

"We anticipated that the foundations would be in river silt, and not very firm, so the plan was made for a plank foundation, but the bottom of the trench at the depth to which it was excavated was found so firm and solid that the only plank used in the foundation was a strip about 16 feet long over the filtered water conduit under the easterly wall."

RESERVOIR.

Plate VII is a view of the reservoir taken from the top of the high-service tower, looking east.

EFFICIENCY OF THE FILTER.

The following tables show the bacterial efficiency of the filter for 1901 and for the first seven months of 1903, and the typhoid fever cases and deaths for 1901 and 1902:

TABLE NO. 1. — BACTERIAL EFFICIENCY OF THE LAWRENCE FILTER.

MONTHLY AVERAGES OF DAILY BACTERIAL ANALYSES OF WATER FROM DIFFERENT PLACES IN THE LAWRENCE DISTRIBUTION SYSTEM.

(Bacteria per cubic centimeter.)

Month .	River at Intake of Filter.	Effluent from Filter.		Outlet of Reservoir.	Tap at City Hall
		Bacteria.	Per c't. of Bac- teria Removed by Filtration.		
1901					
January	5 600	61	98.9	38	34
February	2 500	24	99.0	21	32
March	8 900	50	99.4	22	26
April	1 400	15	98.9	16	17
May	1 400	8	99.4	12	9
June	3 000	58	98.1	49	25
July	1 800	11	99.4	8	12
August	1 600	18	98.8	11	14
September	1 800	15	99.2	12	9
October	1 900	22	98.8	7	11
November	1 300	7	99.5	7	6
December	5 300	22	99.6	24	26
* 1901	3 000	26	99.1	19	18
1903					
January	12 500	58	99.5	70	71
February	7 000	33	99.5	98	75
March	4 100	20	99.5	43	38
April	2 200	12	99.5	15	19
May	4 100	18	99.6	24	24
June	18 200	14	99.9	32	45
July	3 800	18	99.5	24	27

* Average of the monthly averages.

(Figures furnished by State Board of Health.)

TABLE NO. 2. TYPHOID FEVER IN LAWRENCE.

COLLINS.

295

Months.	Cases.	Doubtful.	Imported.	Contracted.	* Canal Water.	** Spring Water.	** Well Water.	Total.	Deaths.	Doubtful.	Imported.	* Canal Water.	** Spring Water.	** Well Water.	Total.
1901															
January	9	..	1	2	4	1	1	9	0	..	..	..	..	..	0
February	2	..	..	..	1	..	1	2	1	..	..	..	..	..	1
March	0	..	..	..	..	..	..	0	0	..	..	..	..	..	0
April	6	..	2	..	3	1	..	6	1	..	..	1	..	..	1
May	8	..	..	..	5	..	..	8	1	..	..	1	..	..	1
June	3	..	1	..	..	2	..	3	0	..	..	..	..	..	0
July	2	..	..	..	2	..	..	2	1	..	..	1	..	..	1
August	12	..	4	..	3	4	1	12	2	..	..	..	1	..	2
September	12	..	3	2	4	1	2	12	0	..	..	..	..	..	0
October	17	1	3	4	5	4	..	17	1	..	..	..	..	..	1
November	13	1	1	2	4	1	..	13	1	..	..	..	..	..	1
December	16	3	2	..	7	..	..	16	4	..	..	..	..	..	4
Total, 1901	100	5	17	10	38	15	5	100	12	..	..	4	1	..	12
1902															
January	8	..	..	2	5	..	..	8	0	..	..	..	..	..	0
February	10	..	..	..	6	..	..	10	0	..	..	..	..	..	0
March	15	2	1	..	10	1	..	15	1	1	..	..	..	..	1
April	8	1	1	2	3	..	..	8	2	1	..	1	..	..	2
May	5	1	2	..	..	..	..	5	2	..	..	..	..	..	2
June	9	1	..	..	4	..	..	9	1	1	..	..	..	..	1
July	5	..	..	..	2	..	1	5	0	..	..	..	..	..	0
August	3	..	..	..	2	..	..	3	0	..	..	..	..	..	0
September	14	1	8	..	1	2	..	14	3	..	..	1	..	..	3
October	4	1	1	..	..	1	..	4	2	1	1	..	..	..	2
November	11	1	..	5	3	..	..	11	1	..	..	1	..	..	1
December	9	..	1	1	5	..	..	9	0	..	..	..	..	..	0
Total, 1902	101	8	14	10	41	4	1	101	12	4	1	3	..	..	12

* Canal Water. — Persons employed in mills where canal water is used and who have had access to that water.

** Spring Water and Well Water. — Persons who have used spring water or well water exclusively.

Estimated population 65 000
 Death-rate 1 in 5 400

1901 68 500
 1902 1 in 5 700

DESCRIPTION OF PROPOSED NEW FILTER.

The new covered slow sand filter to be built at Lawrence, Mass., from designs of Mr. Morris Knowles, C.E., formerly a member of the Lawrence Water Board, will be located west of the present open filter, and will be separated from it by a depressed court with granolithic pavement for the washing and storing of sand.

In general design the new filter will be similar to the filters at Albany, N. Y., and Philadelphia, Pa., with concrete floor, walls, and vaulting. The filter will be 313 feet long and 103 feet wide inside, and will give a net filtering area of about $\frac{3}{4}$ of an acre.

The floor will be built in the form of inverted groined arches, 6 inches thick at the center and 15 inches thick under the piers. The concrete piers supporting the vaulting will be 15 feet center to center and will be 22 inches square down to the sand line, and from this point batter out to 2 feet 6 inches at the base.

The outside walls will be 24 inches thick at the water line, with the outside batter varying from 1 in 5 to 1 in 12, according to their position. The vaulting is to be built of concrete in the form of semi-elliptical groined arches, with a clear span of 13 feet 2 inches, rise of 2 feet 9 inches, 6 inches thick at the crown, and 21 inches thick over the piers. Ventilator openings will be provided for the admission of light and air during scraping. On top of the vaulting a layer of material 3 feet thick will be placed.

The filter will also be provided with a sand run entrance and incline to allow for going in and out of the filter for the purpose of removing or replacing sand.

The underdrain system will consist of a concrete main collector in the form of an arch above the general floor level, running the whole length of the filter, in the center bay. This collector is provided with three manholes, to permit of entrance for cleaning, if occasion demands. From this main collector the laterals start out as 12-inch terra-cotta channel pipe, laid with open joints, and after running a distance of about 15 feet reduce to 6-inch terra-cotta pipe, laid with open joints, and extend to the center of the outside bay.

The plan provides for 12 inches of gravel about the underdrains, and $4\frac{1}{2}$ feet of filter sand.

In the operation of the filter the river water will be carried from

the present gate house by gravity through a 24-inch cast-iron pipe to the inlet chamber in one corner of the filter, where the flow is to be regulated by a regulating valve of special design. The water then overflows the weirs in the walls of this chamber, and is carried by open troughs down along the side walls of the filter. These troughs are provided with orifices of varying sizes, according to their position in the filter, so that the inflowing water is uniformly distributed over the whole area of the bed without disturbing the sand. The water then passes down through the sand and gravel to the laterals, and by them is carried to the main collector already mentioned.

It then passes out through a 24-inch cast-iron pipe and flows to the pump well of the present pumping station, where the flow is regulated by a float valve similar to those at Albany and Philadelphia.

PROCEEDINGS.

JUNE FIELD DAY.

WALTHAM AND NEWTON, MASS.,
June 10, 1903.

The June meeting of the Association was held at Norumbega Park, Auburndale, Mass., on Wednesday, June 10, 1903.

Program. — Sail on Charles River, call at Waltham Pumping Station, dinner at Norumbega Park, visit to Waltham Watch Factory.

Itinerary. — Leave Boston for Waltham at 8.59 A.M. from North Station (Fitchburg Division).

Leave Waltham, Moody Street Bridge, by Charles River steamboat, at 9.30 A.M.

Arrive at Pumping Station of Waltham Water Works at 9.45 A.M.

Leave Pumping Station at 10.15 A.M.

Arrive at Norumbega Park at 10.45 A.M.

Meeting of the Executive Committee at 11 A.M.

Dinner in pavilion at 11.30 A.M.

Arrive at Watch Factory at 1.45 P.M. About two hours spent in passing through the factory.

The following were in attendance:

MEMBERS.

S. A. Agnew, C. H. Baldwin, L. M. Bancroft, G. A. P. Bucknam, M. F. Collins, W. R. Conard, F. W. Dean, H. F. Gibbs, A. S. Glover, J. O. Hall, D. A. Heffernan, H. G. Holden, J. A. Jones, E. W. Kent, Willard Kent, W. A. Kilbourn, G. A. King, C. F. Knowlton, D. A. Makepeace, W. E. Maybury, F. E. Merrill, H. A. Miller, J. W. Moran, Thomas Naylor, G. A. Sanborn, C. W. Sherman, H. O. Smith, J. E. Smith, G. A. Stacy, J. T. Stevens, W. F. Sullivan, W. H. Thomas, D. N. Tower, C. K. Walker, J. C. Whitney, W. P. Whittemore, Frank B. Wilkins, G. E. Winslow, E. T. Wiswall. — 39.

ASSOCIATES.

Ashton Valve Co., by C. W. Houghton; Barr Pumping Engine Co., by H. E. Grant; Builders Iron Foundry, by Frederick N. Connet; Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; Garlock

Packing Co., by Horace Hart; Hersey Mfg. Co., by Albert S. Glover and Walter A. Hersey; William Briggs, by Wm. Woodburn; Henry F. Jenks; Lamb & Ritchie, by H. F. Peck; Lead-Lined Iron Pipe Co., by T. E. Dwyer; National Meter Co., by Charles H. Baldwin and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Perrin, Seamans & Co., by J. C. Campbell; Ross Valve Co., by Wm. Ross; Sweet & Doyle, by H. L. DeWolfe; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by J. P. K. Otis; International Steam Pump Co., by Samuel Harrison. — 21.

GUESTS.

F. E. Hunter, West Newton, Mass.; L. P. Stone, Natick, Mass.; Frank P. Fisk, Milford, N. H.; F. W. Ingersoll, Engineer Pumping Station, Gloucester, Mass.; Mrs. George E. Winslow, Waltham, Mass.; Mrs. Wm. E. Maybury, Braintree, Mass.; Mrs. Samuel Harrison and Mrs. D. S. Dow, Somerville, Mass.; Mrs. Thomas Naylor, Maynard, Mass.; Mrs. Willard Kent, Narragansett Pier, R. I.; R. J. Crowley, Member Water Board, Lowell, Mass.; Miss Almira Winslow, Mrs. C. W. Houghton, J. O. Cheever, Boston, Mass.—14.

After dinner the Association was called to order by President Charles K. Walker; the Secretary read the names of the following applicants for membership, who were recommended by the Executive Committee:

For Resident Member.

Samuel C. Manley, Augusta, Me., President and General Manager Maine Water Company; W. J. Wetherbee, Leominster, Mass., Superintendent and Registrar, Leominster Water Works; M. J. Doherty, Natick, Mass., Engineer Metropolitan Water Works at Pegan Filter Beds.

For Non-Resident Member.

William Booth Bryan, London, England, Engineer-in-Chief East London Water Works Co.; George T. Ingersoll, Schenectady, N. Y., Superintendent of Water Works; J. S. Robinson, Columbia, Tenn., Superintendent of the Columbia Water & Light Co.; Robert N. Ellis, Jacksonville, Fla., Superintendent of Water Works.

On motion, the Secretary was instructed to cast one ballot in favor of the applicants, which he did, and they were thereupon declared elected.

The President announced that Mr. Henry F. Jenks had been appointed a committee to arrange for the exhibits of Associates at the Montreal Convention.

The business meeting then adjourned

EXECUTIVE COMMITTEE.

Records of Meeting of the Executive Committee of the New England Water Works Association, Friday, April 17, 1903, at headquarters, Tremont Temple, Boston, Mass.

Present: President Charles K. Walker, V. C. Hastings, Edwin C. Brooks, George A. Stacy, H. G. Holden, Willard Kent, L. M. Bancroft, Charles W. Sherman, Robert J. Thomas, Frank E. Merrill.

The following letter from Mr. S. E. Tinkham, Secretary of the Boston Society of Civil Engineers, with reference to the admission of the New England Association of Gas Engineers to joint occupancy of rooms in Tremont Temple, was read:

BOSTON SOCIETY OF CIVIL ENGINEERS,
715 TREMONT TEMPLE,
BOSTON, MASS., April 6, 1903.

MR. WILLARD KENT, SEC'Y N. E. W. W. ASSOCIATION,
NARRAGANSETT PIER, R. I.:

Dear Sir, — The New England Association of Gas Engineers has asked this society if arrangements can be made by which that Association can use for its headquarters the rooms now used jointly by the Water Works Association and the Engineers' Society.

The Association of Gas Engineers has a membership of about two hundred men connected with the various gas companies in the New England states. At present it holds one meeting or convention each year at some hotel in Boston, but it is the hope of its officers that by having a place in Boston where its members can drop in when they have a few minutes to spare and examine the periodicals on our tables, the usefulness of the society and the interest of its members may be increased.

The Board of Government of the Engineers' Society have assured the directors of the Gas Association that they viewed with favor any movement tending towards a common headquarters of the several engineering organizations located in Boston, but inasmuch as the rooms were used jointly with the Water Works Association, no definite answer could be given until after consultation with that Association.

In order that the matter may be fully and carefully considered, the Engineers' Society has appointed a committee of three from its Board of Government, who are authorized to represent that society and to act definitely in the matter.

If your Executive Committee look favorably upon this bringing together of organizations having similar objects, it is suggested that a committee from its members be appointed to confer with our committee and see if some arrangement cannot be made beneficial to all interested.

Very truly yours,
S. E. TINKHAM, Secretary.

and after due consideration and a general discussion, Willard Kent, Charles W. Sherman, and L. M. Bancroft were, on motion of Robert J. Thomas, elected a committee with power to act, to confer with the committee from the Board of Government of the Boston Society of Civil Engineers, to consider the question of increase of salary of the assistant secretary and to make such definite arrangements as might be deemed advisable in the premises.

Messrs. Horace G. Holden and Frank E. Merrill of the committee on June and September meetings reported at length with relation to the same, and on request of the committee and by

direction of President Charles K. Walker, Mr. J. O. A. LaForest, of Montreal, was made an additional member of the committee on the September convention.

No further business appearing, the meeting was adjourned without day.

Attest:

WILLARD KENT, *Secretary.*

Records of Meeting of the Executive Committee of the New England Water Works Association held at Norumbega Park, Auburndale, June 10, 1903.

Present: President Charles K. Walker, E. W. Kent, George A. Stacy, H. G. Holden, Willard Kent, L. M. Bancroft, Charles W. Sherman.

The following applications were considered and the applicants recommended for membership in the Association: Samuel C. Manley, Augusta, Me.; W. J. Wetherbee, Leominster, Mass.; M. J. Doherty, Natick, Mass.; Wm. Booth Bryan, Clapton, London; George T. Ingersoll, Schenectady, N. Y.; J. S. Robinson, Columbia, Tenn.; and Robert N. Ellis, Jacksonville, Florida.

Attest:

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association was held on August 13, 1903.

Present: President Charles K. Walker, V. C. Hastings, E. C. Brooks, C. W. Sherman, L. M. Bancroft, R. J. Thomas, G. A. Stacy, and Willard Kent.

The following applications are considered and the applicants recommended for membership in the Association: C. Dwight Sharpe, of Putnam Conn.; Tyler H. Bird, of Belfast, Me.; George S. Brown, of Danielson, Conn.; Bernon E. Helme, of Kingston, R. I.; Phil S. Smith, of Montpelier, Vt.; Thomas William Lesage, Montreal, Canada; S. A. Stearns, Granite, Ill.; George Janin, Montreal, Canada; and Jos. D. Pointer, of Palatka, Fla.

On recommendation of Mr. Sherman the following amendment to the Constitution is approved by the Executive Committee, and it is voted that the proposed amendment be presented to the Association for action at the September Convention:

PROPOSED AMENDMENT TO CONSTITUTION, ARTICLE IV.

Strike out from Section 2 the following:

"which shall include a subscription to the Journal of the New England Water Works Association."

Add a new section as follows:

"SECTION 4. Three dollars of the dues of each member or associate, or such portion thereof as may be required, shall annually be applied to payment of a subscription to the Journal of the New England Water Works Association."

The report of the sub-committee, consisting of Messrs. Sherman, Bancroft, and Kent, on the sub-lease of Association headquarters and salary of assistant secretary, is made as follows: That the following agreement has been made with the Boston Society of Civil Engineers:

Memorandum of an agreement made April 30, 1903, by a committee representing the Executive Committee of the New England Water Works Association and a committee representing the Board of Government of the Boston Society of Civil Engineers.

First. That authority be given to the New England Association of Gas Engineers to use the rooms now occupied jointly by the two societies and to place upon the shelves such books as the Gas Association desire.

Second. That the price of this use of the rooms to be paid by the Gas Association be fixed at one hundred dollars (\$100) for one year.

Third. That the income from this rental constitute an Improvement Fund for the improvement of the rooms and furniture, to be expended with the approval of the secretaries of the two societies.

WILLARD KENT,

CHARLES W. SHERMAN,

LEWIS M. BANCROFT,

E. W. HOWE,

S. E. TINKHAM,

F. P. MCKIBBEN,

*Committee of the New England Water
Works Association.*

*Committee of the Boston Society of
Civil Engineers.*

and that the salary of the assistant secretary has been made \$35 per month.

Whereupon it is voted that the report of the sub-committee be accepted and their action approved.

Voted: That William Lyman Underwood be invited to address the Association at Montreal on the subject of "Mosquitoes, and Suggestions for their Extermination," and that his expenses in connection therewith be borne by the Association.

Adjourned.

WILLARD KENT, *Secretary.*

OBITUARY.

CHARLES F. PARKS, who was elected a member of the Association on December 11, 1889, died on April 21, 1903.

He was born April 10, 1850, and was educated as a civil engineer at the Massachusetts Institute of Technology. After leaving the Institute he began practice in general engineering work at Waltham, Mass., and later became engineer for the town. In 1885 he formed a partnership with Mr. William Wheeler under the firm name of Wheeler & Parks; the firm built the water works at Belfast, Me.; Exeter and Derry, N. H.; Putnam, Danielson, Portland, Stonington, and Mystic, Conn.; Braintree and Cottage City, Mass.; Palatka, Fla.; Paris and Winchester, Ky.; and also reconstructed the works at Ashland, Wis., and Knoxville, Tenn. The partnership was dissolved in 1894. Mr. Parks subsequently built the water works at Pittsfield, Me., but thereafter until the time of his death he devoted the greater part of his time to his private interests and to the care of his health.

JAMES M. GALE, for forty years chief engineer of the water department of Glasgow, Scotland, died September 7, 1903. He was born in Ayr in 1830, and at the age of fourteen he joined the engineering staff of an elder brother, William Gale, then engineer for the Gorbals Water Company, with whom he remained until 1855. During this time he attended the famous engineering lectures of Professor Rankine and the mathematical lectures of Professor Laing. In 1855 he was appointed resident engineer on the city section of the Glasgow water works, then being constructed under J. F. Bateman, and on their completion in 1859 he was appointed chief engineer. From that time until 1902 he was in continuous charge of the works. Under his direction the waste of water was curtailed and many important new works built, including a second aqueduct from Loch Katrine.

Mr. Gale was elected an Honorary Member of the New England Water Works Association on January 16, 1889.

NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XVII.

December, 1903.

No. 4.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

SOME SIX-INCH METER TESTS AND HOW THEY WERE MADE.

BY FRANK C. KIMBALL, SUPERINTENDENT OF WATER WORKS,
KNOXVILLE, TENN.

[Presented September 10, 1903.]

The Knoxville Water Company, through its treasurer, last winter, deeming it expedient to know the retardation or loss of pressure caused by 6-inch meters of certain types and makes, instructed the writer to investigate and report upon this subject as fully as possible. Interviews with various meter manufacturers and others, as well as an examination of such literature as might bear on this subject, disclosed the fact that with very few exceptions, no information upon the matter under discussion was available to the water works fraternity. The two most notable exceptions to this statement are the tests made by Mr. E. V. French in 1896 and 1897, of one 3-inch, six 4-inch, one 6-inch, and one 8-inch meter, some results of which were published in Volume XII, page 73, of the JOURNAL of this Association; and the testing of two 6-inch meters, incident to the testing of numerous fire hydrants, by Mr. Charles L. Newcomb, M. Am. Soc. M. E., at Holyoke, Mass., in 1897 and 1898, the results of which were published in Volume XX of the Transactions of that Society; and to these two valuable contributions on this subject I would recommend your careful attention. As, however, this information did not fully answer the requirements of our company, it

was thought desirable to make tests ourselves along these lines. With this end in view a letter was addressed in March last to all known meter manufacturers in the country, asking them to submit a 6-inch meter of each type made by them, the same to be subject to tests, including amongst others the following:

First. To determine the loss of head or retardation of flow by the passage through them of varying quantities of water, say from 25 cubic feet per minute to as large an amount as would flow under the conditions resulting, possibly as high as 300 to 400 cubic feet per minute in some types of meters.

Second. To determine how small a stream each meter would register, and with what per cent. of slip or leakage, or, in other words, what the unrecorded flow will amount to on various discharges, from the smallest stream possible to register, as well as their accuracy on various-sized streams up to their capacity.

It was also stated in the same letter of invitation that the results of such tests might be used in discussion before this or other associations, and for this reason we desired to have as many kinds of meters represented as possible.

Of the nine companies to whom this invitation was addressed, one replied that it made nothing larger than 2-inch meters, and therefore could not accept; two declined to send, while another agreed to send one, but failed to do so; leaving five who responded by sending nine different meters. As those submitted included four of the so-called rotary or piston type,—namely, the Hersey Rotary, the Crown, the Empire, and the Union; two of the disc type, the Hersey Disc and the Keystone of the Pittsburg Company; and three of the so-called current type, the Torrent, the Gem, and the Standard,—a sufficiently wide range of styles and kinds was tested to gain fairly good comparative results, so that from the data herewith submitted we may be assisted in selecting such type and style of meter as will best answer the particular purpose for which meters may be desired.

As, however, new types of meters are occasionally placed upon the market, and as meters already known are from time to time improved or claims made of improvements, and as for lack of testing and knowledge of them their adoption is a matter of uncertainty, with water departments, it was assumed that this Association would be as much interested in the details of

the apparatus and the method of testing as in the results obtained, more particularly as the expense of installing a permanent testing plant for large meters is not great, comparatively speaking. By the installation of such testing plants in several of the larger cities within the limits of the members of this Association, there would result, in our opinion, a toning up, as it were, of the meter manufacturers to a more thorough consideration of the requirements of both water departments and insurance underwriters. There would also be a more potent incentive to manufacturers to turn out large-sized meters which would fulfill the requirements of close registration on both small and large streams, knowing that such meters would undergo the same care in testing as is now so generally given to the smaller, or house meters. In addition to this, such a system of tests would give the managers of water plants sufficient data to enable them to determine the selection of the meter best suited to the particular work it is to do, and to see, when it is received and before placing, that it would do it, and thus do away with that large amount of guesswork, now frequently indulged in, as to the capacity and performance of meters above 2 inches in size, to the disadvantage at times of both the water departments and consumers, neither being satisfied that they are not getting the worst end of the bargain. That there is uncertainty, even in the minds of meter manufacturers, as to just what their own meters in the larger sizes will do was particularly emphasized to the writer, when, in asking one of them how close a certain meter of his would register on certain-sized streams and how much retardation there would be in it under certain flows, the reply was made that, to his knowledge, but one meter company in the country was in position to make such tests with any degree of accuracy on large-sized meters; and, naturally supposing him to be referring to his own company, upon asking what company it was, the rather surprising answer was received that it was a competitor of his. Asking him then how he knew what his meters would do, the reply was that very careful experiments were made upon all sizes of meters up to and including 2-inch, and occasionally on 3- and 4-inch where possible, and from these the construction details of the larger sizes were designed and their effectiveness obtained by comparison. Assuming the above to be facts, a

more definite knowledge by water-works officials of what can or cannot be done by meters, which at the present time are purchased largely upon faith in the manufacturer, is a necessity, although I must not be understood as saying that any of the manufacturers would intentionally misstate the performance of their particular meters. On the contrary, I have more than once been informed by them, when asking for certain facts, that while they thought certain results would be attained, they could not positively guarantee that they would be; and their statements to me as a rule have been conservative rather than otherwise. For these reasons I do not hesitate to trespass upon your time to explain rather fully how these tests were made, in the hope that it will bring out discussion as to the needs of such testing apparatus and suggestions as to how the methods employed by us may be improved, with the further result that meter manufacturers or others may supply the trade with suitable apparatus for this purpose.

The first requisites for tests of this description are an adequate supply of water and facilities for quickly getting rid of it, as at times possibly a discharge of 2 500 to 3 000 gallons per minute or even more will be desired. The tests described were made at the river pumping station of the Knoxville Water Company, which is situated upon the northerly bank of the Tennessee River at Knoxville, Tenn., a general view of which is shown on Plate I. Reference to Fig. 1 will also show, in the lower left-hand corner, a general plan of the pumping station buildings, river bank, and intake tower. The water for these tests was obtained through the 14-inch main shown on that plan, this force main coming directly from the low-service reservoir of the company, which is about 2 625 feet from the point where the 6-inch wrought-iron pipe shown is taken off. This 6-inch pipe, which was laid expressly for this work, was 100 feet in length from its connection with the 14-inch main to piezometer ring "B" on Fig. 1. High-water line in the reservoir is at elevation 247.5, low-water line in the river being grade 10, and the general level of the testing apparatus, 53.5. During the progress of the tests the reservoir ranged from full to 4 feet out, making its average elevation about 245.5 and the average available static head 192 feet, or a little over 83 pounds pressure when no water

Details of Apparatus
 used in Ginch Meter Experiments of
 KNOXVILLE WATER COMPANY
 Knoxville, Tenn. May-1903
 Made under the Direction of
 FRANK C. KIMBALL Junr

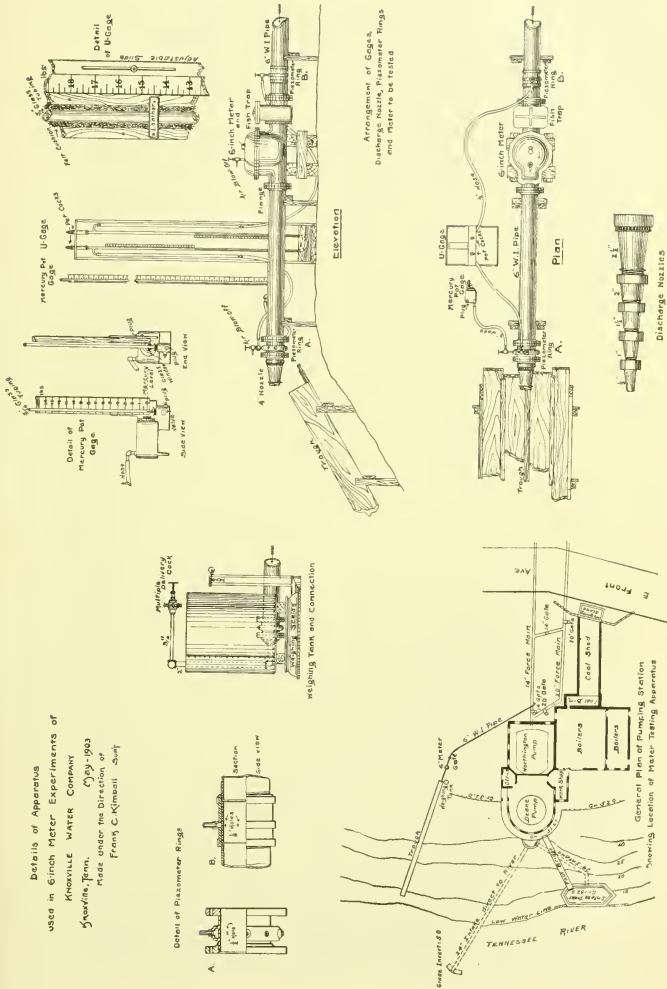
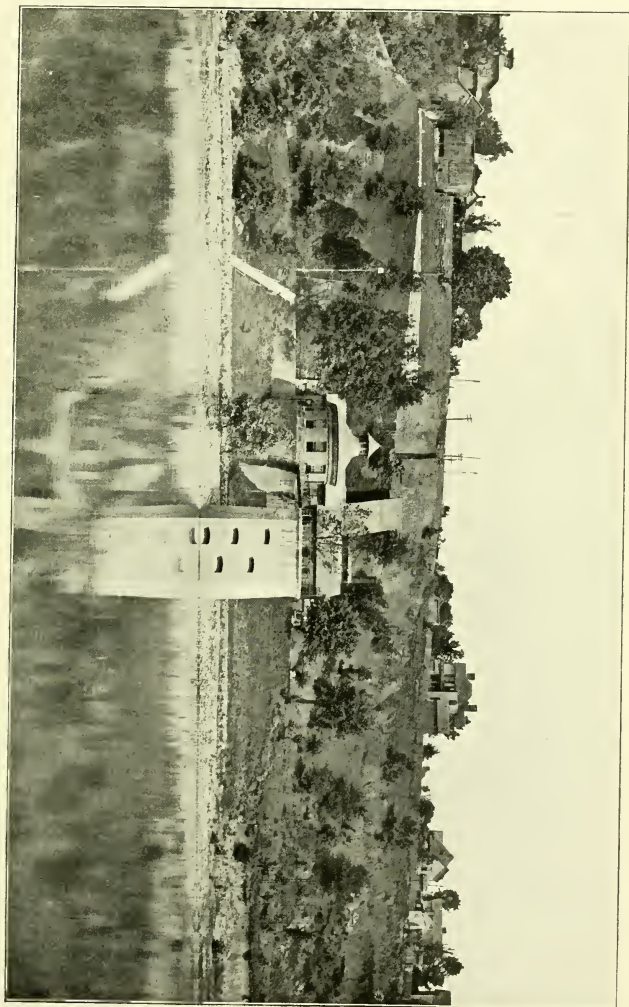


FIG. 1.

was being drawn. This 14-inch main, being a reserve force main and not ordinarily used for pumping, and coming as it did directly from the reservoir, was well fitted for this purpose and gave pressures fairly free from vibrations and with comparatively small loss of head by friction under the heavier flows used. The water after passing through the meter was discharged into the air, an open trough shown both on Plate I and in Fig. 1 catching it as it fell from the discharge nozzle and conducting it into the river without washing the banks, although some of these streams were projected well into the river with very little of the water falling into the trough.

METHODS AND APPARATUS.

The general methods used in these nozzle tests followed those described by Mr. John R. Freeman in his very excellent paper on "Hydraulics of Fire Streams," as published in Volume XXI of the Transactions of the American Society of Civil Engineers, and those in his paper on "The Nozzle as an Accurate Water Meter," published in the Transactions of the same society, Volume XXIV, and to these valuable papers I am largely indebted for ways and methods used. Similar methods were employed by Mr. E. V. French and Mr. C. E. Newcomb in making the tests heretofore referred to. Fig. 1 shows in detail the arrangement of the apparatus. Measurements of water pressure were in all cases taken by means of an open mercury column with scale graduated to read directly in pounds pressure per square inch, the glass tube being about $\frac{5}{16}$ inch in diameter internally and $\frac{5}{8}$ outside. This tube, by means of a stuffing box, was connected to the outlet of the mercury cistern, this outlet being from the bottom of the cistern, and controlled by a small valve so that the mercury could be shut off if necessary at any time. The mercury cistern was an aluminum pot, rectangular in plan and about 4 by 5 inches in size by about 3 inches high, to one side of which was fastened the scaleboard and glass tubing. A small circular glass window in this side of the cistern allowed the zero of the scale to be compared at all times with the level of the mercury in the cistern, which level was compared several times daily and mercury added if from leakage any had escaped, which, however, was seldom. Two $\frac{1}{4}$ -inch connections



RIVER PUMPING STATION, KNOXVILLE WATER CO., KNOXVILLE, TENN.

were in the top of the cistern, one of which had a short nipple, an elbow, and another nipple of $\frac{1}{4}$ -inch pipe, to which stout rubber hose was attached by means of wire wrapping and twisting, which hose was then carried to piezometer ring "A." The other connection in the top of the cistern was used as an air valve, a $\frac{1}{4}$ -inch valve being screwed into it and the air frequently blown out. This orifice was also used to add mercury as needed. As the pressure increased and the mercury in the cistern lowered, the height of the mercury column was also lowered, but to a very small amount. In graduating the scale, allowance was made for this, with the result that with cistern and glass tube of the sizes used, a mercury pound was 2.0382 inches, the height of a mercury column corresponding to one pound per square inch pressure being 2.0452 inches at 60° F. As care was taken to set the zero of the scale at the same level as the outlet of the nozzles, pressures were read direct without correction for difference in level. Where it is not practicable to set the zero of the scale on the same level as the center of the discharging nozzle, it may be set at any level and correction made for the difference, which difference may be found either with an engineer's level or by filling the nozzle with water to its center and noting where it rises on the scale, this latter method, where possible, being the easier and less liable to error. The scale was graduated in pounds and tenths to eighty-seven pounds, being thus about 15 feet high, and to read it, a light ladder was attached to the framework, supporting it. The glass tubing was in two sections, joined together by a sleeve of rubber hose wrapped with wire and twisted tight. If care is taken in making the joints and connections, no trouble from leaks need be feared, although more care is required to make a joint tight against mercury than against water.

The retardation or loss of pressure in the meters was measured by means of a "U" gage, which is simply two glass tubes similar to the one used for measuring the pressure in the open column, connected together at the bottom and about half filled with mercury. Near the top of these tubes from a tee is taken off a hose connection on each side, one of which is connected to a piezometer ring back of the meter, shown on Fig. 1 as piezometer ring "B," and the other to a similar ring shown as piezometer ring "A." In the tops of these tubes are inserted

pet cocks, connected thereto by rubber hose sleeves wired tightly, these being used not only when water is first let into the gage, but at frequent intervals thereafter, to blow out any air that may have accumulated therein. In the gage shown here, sliding scales were used on each arm, one reading upward and the other down, the zero on both being carefully brought to the level of the two mercury columns when everything was at rest. Care in setting this gage at any particular height need not be taken, as it shows simply differences in pressures which will be the same regardless of the height of the gage itself; but the graduations of the scale to read pounds direct will be slightly different from those of the open column, as the weight of the column of water has to be taken into consideration as well as the mercury, and doing this will make the height of the mercury column under these conditions 2.2051 inches for one pound difference in pressure; in other words, for each 2.2051 inches difference between the height of mercury in the two tubes there is a loss of one pound pressure. If, therefore, the two scales are graduated for mercury pounds and tenths of a pound as above, and the top of one and bottom of the other are brought to a level with both columns of mercury with everything at rest, by reading simultaneously both scales on the gage when in operation, their sum will give the total loss of pressure or retardation between the piezometer rings.

Two piezometer rings should be used, one back of the meter to be tested and from 5 to 10 feet ahead of any gate, elbow, or other possible means of deflection of the current of water, and the other ahead of the meter and not less than the same distance from it, so that changes in direction of the water in passing through gates, elbows, meters, etc., will have time to substantially straighten out before reaching the piezometer rings, thus largely avoiding false readings incident to eddies and unequal pressure. On Fig. 1 are shown two different styles of piezometer rings, the one marked "A" being of cast iron, flanged, while the one marked "B" is of wrought iron and composition fitted for screw connections. In brief, any truly smooth piece of pipe, of practically exact diameter, surrounded on the outside with an annular ring, having three or more $\frac{1}{16}$ - or $\frac{1}{8}$ -inch holes drilled through into the pipe at equal distances apart, care being taken to have the orifices at right angles with the pipe, on circum-

ferential line, and without burrs or roughness on the inside of the pipe, will make a good piezometer ring. The reason for the use of such ring is that if, through any cause, the direction of the current of water is changed or impinges harder upon one side of the pipe than upon the other, the pressure within the annular ring, which is imparted to the water through the various orifices, will be equalized and correctly indicated. The same results for all practical purposes, perhaps, with care in drilling, can be obtained by drilling three or more holes directly into the pipe under the above conditions, and screwing in nipples, connecting them all together outside into one line, to which the hose running to the gages is connected; but as there is more liability of roughness under such arrangement, due to nipples or burrs projecting into the pipe, the use of regularly constructed rings is recommended. Into the annular ring above mentioned should be tapped one or more holes $\frac{1}{4}$ -inch in size, into which nipples can be screwed and connections made with the gages by means of hose or otherwise. Between the nipples and the hose it is advisable to place a $\frac{1}{4}$ -inch valve to regulate the flow to the gages, and this is also useful, where there is much vibration, to throttle the pulsations down as low as possible, although in so doing extreme care should be taken not to shut down too closely. Some movement in the mercury column should be noticeable at all times so as to be certain that there is a free opening to transmit the pressure. An air valve on the upper side of the piezometer rings will be of assistance in removing the air from the rings and preventing it getting into the mercury pot or tubes. In our apparatus, as shown, one leg of the "U" gage was connected to a tap in the top of piezometer ring "A" with a blow-off cock above it, while the open-end mercury gage was connected to another tap in the side of the same piezometer ring.

Among the most important parts of the apparatus needed, for discharges of thirty gallons per minute and upwards, are the nozzles, and, in the opinion of the writer, to have as high initial pressures as possible these should range in size of orifice from at least $\frac{1}{2}$ inch to 4 inches, and under some conditions perhaps to 5 inches. The nozzles used in these tests were a 4-inch and a 2 $\frac{1}{2}$ -inch, kindly loaned us, with other apparatus, by the Factory Mutual Fire Insurance Companies of Boston, and a 2-inch, a 1 $\frac{1}{2}$ -

inch, a 1-inch, and a $\frac{1}{2}$ -inch which we had made for the purpose. These are all fitted with iron-pipe threads, so that one screwed on the next in size as shown. An additional nozzle of 3 inches in size would be useful in a permanent plant, although various rates of discharge can be obtained with any size nozzle by throttling the controlling gate back of the first piezometer ring. In the construction of these nozzles Mr. Freeman, in his article on "The Nozzle as an Accurate Water Meter," page 511, states the following requisites for good work:

"A smoothly tapering nozzle whose sides converge at an angle of somewhere between 5° and $7\frac{1}{2}^\circ$ to the axis, and whose interior is smoothly polished for a distance back equal to, say, three or four times the diameter of the orifice."

Also, in speaking of using different-sized nozzles, one screwed on the other, substantially as shown on Fig. 1, herein, he says, page 512, *ibid.*:

"The smaller nozzles can be detached, leaving the larger ones in place, and thus securing an orifice of any desired size. Intermediate sizes can be attached to the same base, as, for instance, a $2\frac{1}{2}$ -inch could be screwed on to the end of the 3-inch in place of the 2-inch as shown [speaking of a sketch in his report]. The inside corner at the extreme end of each nozzle in the series should be rounded out to lessen the chance of bruising. A straight cylindrical tip of uniform diameter for a length equal to about half the diameter of nozzle is formed at the end of each, and the angle where this unites with the conical portion is smoothly rounded off."

These nozzles should be connected directly with the outer piezometer ring so that the pressures obtained by means of this ring will be practically those at the base of the nozzle. In all cases of either flanged or nipple connections of the various parts of the apparatus, care should be taken that gaskets do not project into the barrel of the pipe, and that all burrs and rough edges on nipples are removed so that no obstruction will be presented to the easy and straight flow of the water.

It is assumed that the nozzles have been carefully calibrated, and it is desirable, for use with a permanent plant, to construct discharge tables for each nozzle. For ordinary work, tables giving the discharge for each pound or half-pound pressure,

within the range of pressures that will be used, will be sufficient, and pressures between calculated points can be interpolated. Where considerable use is to be made of the nozzle determinations, time will be saved and more accurate results will be obtained by extending the table to include discharges for each tenth of a pound. This is as close, taking into consideration the vibrations of the mercury column, as pressures will probably be read, but when possible, by means of a vernier or by estimation, to read closer, interpolated discharges will be as accurate as can be desired. A more rapid but not as accurate way of obtaining quantities would be by calculating a sufficient number of discharges at various pressures to enable a curve to be constructed, either on ordinary or logarithmic cross-section paper, and the discharge read directly from such curves for the recorded pressure. The formula from which to determine such discharge is given by Mr. Freeman as follows:

$$G = \frac{29.83 \ c \ d^2}{\sqrt{1 - c^2} \left(\frac{d}{D}\right)^4} \sqrt{p}$$

Where G = gallons discharged per minute.

c = Coefficient of discharge of nozzle used.

d = diameter of orifice of discharge, in inches.

D = diameter of inside, or barrel, or piezometer ring, in inches.

p = indicated pressure in pounds per square inch at base of nozzle.

An inspection of this formula will show that where the diameter of the nozzle and piezometer rings are determined and the value of c fixed, the formula can be reduced to a constant, by which it is only necessary to multiply the square root of the pressure in pounds to obtain the discharge in gallons per minute. In this formula the only uncertain factor is the value of c , and this, with nozzles constructed as directed, Mr. Freeman has, through a very elaborate series of experiments, determined to be about .995. The smaller nozzles used by the writer, however, were not as smooth and regular as could be desired, and a series of experiments were made to determine what the coefficients of discharge of these particular nozzles were. The values of c , as so determined, as well as actual diameters of the nozzles used, are as follows:

<i>Nominal Diameter, Inches.</i>	<i>Actual Diameter, Inches.</i>	<i>Coefficient of Discharge = c.</i>
$\frac{1}{2}$	0.509	.965
1	1.048	.970
$1\frac{1}{2}$	1.503	.980
2	1.998	.990
$2\frac{1}{2}$	2.463	.995
4	3.954	.995

Future experiments, however, should be cautioned as regards using these particular coefficients, — except as to the last two, — as the writer firmly believes from results obtained that with nozzles constructed as directed, for all sizes from $\frac{1}{2}$ inch up, the value of c will range from .990 to .995. Practice in experimental work of this kind, especially with two or more of the larger meters of standard makes, will soon enable one to so adjust this value as to bring all sized nozzles into a consistent relation one with the other, and also with the meters, after which such value may be used with confidence.

We are now ready to connect up the meter, and with apparatus properly adjusted as shown, we may proceed to determine its accuracy, capacity, and limitations.

In starting a test, water should be turned on and allowed to run long enough to produce normal conditions. Care should be taken that all air is expelled from meters, piezometers, connecting hose, pipes, etc., to avoid vibrations in the mercury columns. If vibrations to any extent continue, they may be partially checked by throttling the controlling valves to the gages, being careful not to entirely shut them off. With everything running in good shape, at the instant the index hand of the meter points to an even number, time should be taken with a good stop watch, and readings of both open mercury gage and of "U" gage should begin. These should be read every minute if columns are fairly steady, otherwise readings every half minute or, in extreme cases of variation, even oftener may be required. These observations should be continued until an even number of cubic feet has been registered by the meter, when, as the index hand points to its proper mark, watch should be stopped, time read, gage readings averaged, and all recorded, completing that test. The length of each run should be sufficient to as nearly as possible eliminate errors of observation either of time or of index hand of meter, and probably should never be less than three minutes. A run of a definite number of minutes

rather than of a definite number of cubic feet might be made, but it is much easier to start and stop a watch instantly than at a given moment to accurately read a fast-moving index hand. Tests should be repeated under the same conditions as nearly as possible, and so continued until the observer in charge is satisfied with the correctness of the results. Experience will shortly enable one to so handle a stop watch as not to vary more than one fifth of a second in an observation and to read a slightly vibrating mercury column within one tenth of a pound, although at times observations may appear so erratic as to make it advisable to discard them entirely. A good observer, however, will seldom allow this to occur. In general, little or no trouble should be experienced by any member of this Association in getting correct results after suitable practice. This is a class of experiments where as much depends upon the personal factor as upon the apparatus employed.

All tests for the purpose of determining the registration of meters upon small flows were made by discharging into a tank upon a pair of scales, the tank holding about 15 cubic feet of water. The flange connecting the nozzles to the outer piezometer ring was unbolted, and another flange, tapped for 2-inch pipe, bolted on. This 2-inch was further reduced to $\frac{3}{4}$ -inch pipe, and this size was carried over the tank and water discharged into it through a multiple discharge cock, all as shown on Fig. 1, and under substantially the same conditions as are used by us all when testing smaller meters, the weight of the water being used in comparison with the registration of the meter. The only departure from ordinary practice, perhaps, was in taking the time required to discharge specified quantities of water, so that results could be stated in gallons per minute, as being more expressive than otherwise.

RESULTS OF TESTS.

The retardation or loss of pressure in the nine 6-inch meters tested under the direction of the writer is graphically shown on Fig. 2, while the same results are given in Table No. 1 in another form. These are the losses due to the meter alone, experiments having been made to determine the loss of pressure between the piezometer rings, and deductions from the total losses made accordingly.

In Table No. 2 is shown the sensitiveness of these meters in the registration of small flows, that is, those experiments made by means of the weighing tank; while Table No. 3 gives the accuracy on large flows as determined by the nozzle discharges, using the coefficients of discharge previously given.

Table No. 4 shows the approximate number of feet of ordinary straight cast-iron pipe that would cause the same retardation or loss of head under a flow of 500 gallons per minute, or with a velocity equivalent to 5.67 feet per second.

These tables need very little explanation. On Fig. 2 the positions of the experimental points are shown by dots. These so nearly correspond to parabolic curves that, without making the claim that the retardation of any meter follows exactly this law, these curves have all been drawn as parabolas. Further experiments along these lines will be necessary if it is desired to absolutely demonstrate this as a law, but it is believed that for all practical purposes a parabolic curve represents the retardation of a meter, so that given one accurate determination of a point in such curve, it is possible to construct a curve or table of retardation to any extent desired. Following this principle, Table No. 1 has been calculated. The actual observations for retardation alone did not exceed thirty-three pounds loss of pressure, the limit of the "U" gage used, and all retardations in excess of this amount are calculated. In no case, however, has the limit of retardation been carried beyond the actual discharge of the meter in gallons per minute. On Fig. 2 the full line indicates the extent of actual observations of retardation, while the dotted line in extension thereof indicates the calculated retardation at the maximum flow obtained in these experiments.

In comparing results shown in Table No. 2 — "Sensitiveness of Six-Inch Meters in the Registration of Small Flows" — it should be borne in mind that all the meters except the Crown, Empire, and Gem had as their smallest dial one requiring a discharge of 100 cubic feet to allow the index hand to make one revolution. Those dials were, as is usual, divided into ten parts; and while care undoubtedly was taken to make these subdivisions substantially equal, as in no case was the spindle to which the index hand was attached accurately centered within the dial, and as 10 cubic feet was all that could easily be weighed in the weighing

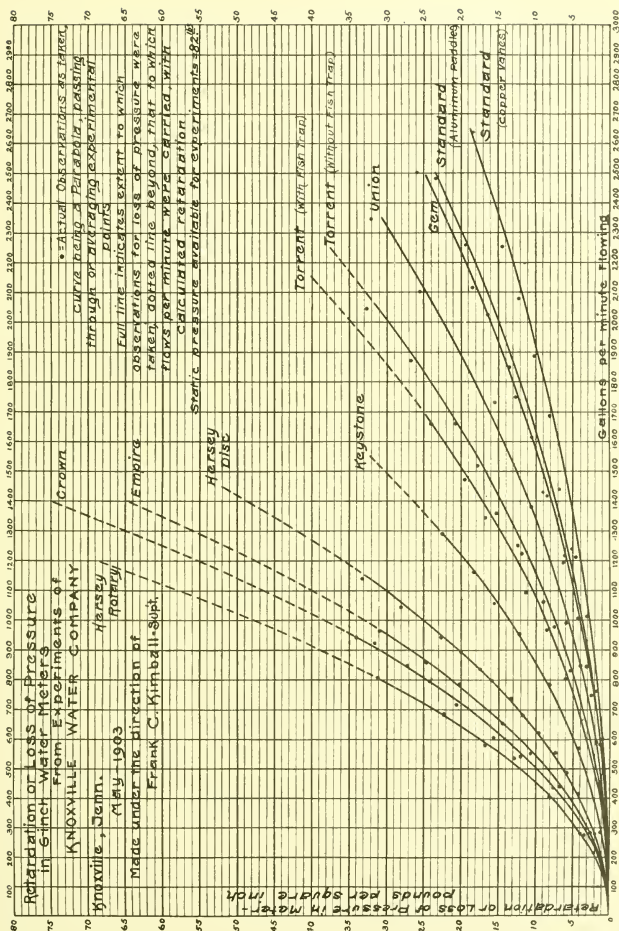


FIG. 2.

tank used, at each experiment, there is a possible slight error in these observations, due both to this eccentricity of the index hand within the dial and to the eye of the observer in noting and stopping the flow exactly on the line indicating one-tenth part of the circumference of this small dial, or 10 cubic feet. In nearly all cases, two or more observations were taken of the same sized stream, and by taking the average of these, it resulted in materially reducing the liability of error of observation and to some extent the error due to eccentricity of the index hand and dial. To determine, however, how much error might exist, due to these causes, experiments were made to see how near 10 per cent. of 100 cubic feet each subdivision of a dial could read, the determinations being checked by the weight of the discharged water. A series of such experiments demonstrated that the maximum observation was 10.46 per cent. of the whole, the minimum observation being 9.64 per cent., while the average error for 10 feet, due to these two causes, was 2.15 per cent., — both plus and minus. Thus, while the average of the readings from which the main results are determined probably reduced the error to a point much lower than this, still it was thought desirable to mention these facts, as the recorded results in some cases, without such explanation, might appear somewhat erratic. In several experiments where the sum of ten 10-cubic foot observations was compared with 100-cubic foot discharges using the same dial and same observer, the maximum error of observation and weight combined did not exceed 0.32 per cent.

In Table No. 3, where two rates of flow per minute for one nozzle are given, they are the approximate minimum and maximum flow through that sized orifice. This difference in flow is brought about by having the controlling gate back of the meter partially or wholly open, so as to produce varying rates of discharge per minute, and intermediate to what would result were gates always full open. With the $\frac{1}{2}$ -inch and 1-inch nozzles, this practice was seldom necessary, but was followed in nearly all cases with the $1\frac{1}{2}$ -inch and larger sizes. The first five meters shown in this table were, in the use of the 4-inch nozzle, run much beyond their rated capacity, so much so that in some of them it is apparent that the working parts of the meter could not keep pace with the flow, and for this reason the average per cent. of meter discharge to nozzle discharge,

shown in the last column, should not be taken as the actual performance of these meters without taking this fact into consideration. To construct this table the average of all experiments made with the same nozzle, meter, and approximate rate of flow was taken.

Table No. 4 is calculated from the observed losses of head, with the aid of "Diagrams and Hydraulic Data Relating to the Flow of Water in Cast-Iron Pipes," by Leonard Metcalf, Assoc. M. Am. Soc. C. E., Boston, Mass., as published in the *Engineering Record*, June 20, 1903, and needs no further explanation.

EFFECT OF FISH TRAPS ON METERS.

Of the meters tested the Hersey Rotary, Hersey Disc, Union, and Standard had no fish trap or strainer as a part of their meter. Tests were made upon the others to determine what the effect of these strainers was.

The effect of the Torrent meter is shown on Fig. 2 and in Table No. 1 both with and without strainer. The area of the openings in this strainer is equivalent to 1.25 times that of a 6-inch pipe.

The Crown meter is shown with strainer. Without, the retardation averages about 10 per cent. less, the area of openings in this strainer being about 2.25 times that of a 6-inch pipe.

The Empire meter shows no difference whether with or without strainer, the area of openings being about 3 times that of a 6-inch pipe.

The Keystone meter is shown with a strainer which has openings equivalent to 1.9 the area of a 6-inch pipe. The retardation without strainer averages about 10 per cent. less than with.

The Gem meter shows no appreciable difference, either with or without strainer, the area of openings in which is about 3 times that of a 6-inch pipe.

These can be considered as *minimum* obstructions or retardation due to the strainers or fish traps furnished with these several meters. The water used in these experiments was all filtered and came directly from the clear water reservoir of the plant, through a pipe from which all mud and sediment had been blown out. In ordinary practice, where little or no water is usually drawn through these meters, and especially with water containing sediment in the shape of mud, sticks, leaves, etc., when a large draft is

made through them, as in case of fire, the loss by stopping up more or less of the small holes in the strainer will be much more. For this reason the writer believes that where strainers are necessary, and perhaps in all cases, a special fish trap should be used, with an area of openings equivalent to about five or six times that of a 6-inch pipe. This can be bolted directly to the meter, though independent of it, and should be provided with a removable cover or hand plate to insure ease in inspecting and cleaning. Where meters are attached to a fire protection system, the strainer should be inspected as regularly and as often as are the other portions of the system. From tests made, an area of openings three times that of the area of the pipe seems adequate to eliminate friction loss when clean; and with area of twice this amount, something over half can become clogged or covered without affecting the flow of water, and with ordinary inspection and a water supply suitable for domestic uses, this should insure perfect safety in the use of such fish trap.

SPECIAL TESTS AND CONDITIONS.

A strong point usually made by insurance inspectors against the use of rotary, piston, or disc meters upon fire protection lines is their liability to clog, stop, and break by foreign matter carried into them from pipe lines and lodging in their moving parts and wedging. While this can hardly result if use is made of large-area strainers, some experiments were made along these lines.

The Crown meter was completely blocked by the insertion of two wooden wedges between piston and casing. In this condition, the following results were obtained:

<i>Size Nozzle Used, Inches.</i>	<i>Discharge, Gallons per Minute.</i>	<i>Loss of Pressure, Pounds.</i>
1	204	40
1½	338	55
2	479	62
2½	575	69

While the test with 2½-inch nozzle was under way, seven of the eight screws fastening the interior cover plate to the casing gave way, allowing this plate to lift. The meter in this shape, still blocked, however, so that the piston could not move, discharged with 2½-inch nozzle at the rate of 1 329 gallons per minute, with loss of pressure of 18.3 pounds, and with 4-inch nozzle, 2 128 gallons, with loss of pressure of 24 pounds. This would seem to show



FIG. 1. — GENERAL VIEW OF APPARATUS USED.

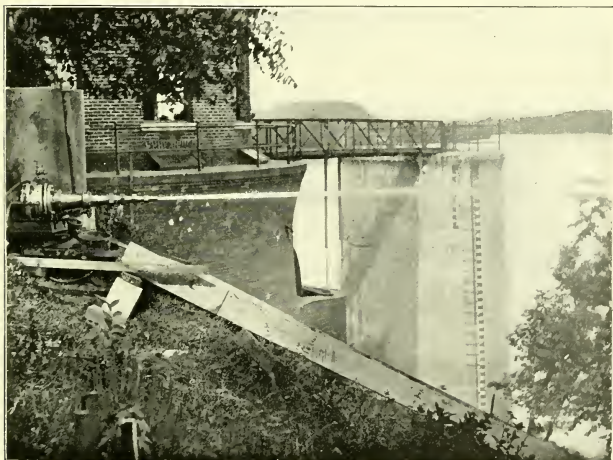


FIG. 2. — DISCHARGE THROUGH $\frac{1}{2}$ -INCH NOZZLE. 67 GALLONS PER MINUTE (EMPIRE METER).

that a sudden stopping of this meter by piston becoming blocked would result in tearing away the cover plate, allowing water to flow with much more freedom than before. After this test it was found that the cover plate had been slightly sprung. This was straightened by a hammer, on the ground, bolted back into place, and the meter tested again on small flows. Results fully as accurate as before it broke were obtained, showing that no injury to the meter itself to any extent had resulted.

The Gem meter also had its working parts completely blocked, and in this condition the following results were obtained:

<i>Size Nozzle Used, Inches.</i>	<i>Discharge, Gallons per Minute.</i>	<i>Loss of Pressure, Pounds.</i>	<i>Increased Loss over Meter running Free, Pounds.</i>
2	1003	4.5	0.5
2½	1411	9.3	1.3
4	2457	26.8	2.9

This shows a difference in loss of pressure as between meter running free and with moving parts blocked, of between 10 per cent. and 15 per cent. only.

The effect upon the flow through a disc meter when disc is broken and the pieces wedged by the force of the water into the outlet was shown by the Hersey Disc. This meter was tested to a finish, so far as the disc was concerned. While discharging at a rate of 1 455 gallons per minute (guaranteed capacity being 900 gallons, an excess of upwards of 60 per cent. in flow) the disc broke into several pieces. Without in any way changing the conditions of supply, a discharge was obtained, as shown by the nozzle, through this meter of about 1 218 gallons per minute, and with substantially the same loss of head as before it broke. This would indicate a discharge, under the most adverse conditions possible in a meter of this character, of about 86 per cent. of the free flow of such meter, certainly not enough of a difference to warrant discarding meters of this type on account of liability of breakage at such high velocities. The replacement of the disc with a new one was all that was required to again place the meter in proper working order.

The Keystone disc meter, which also has a guaranteed capacity of only 900 gallons per minute, was tested to a discharge of 1 518 gallons, being an excessive discharge of about 69 per cent., at which rate this disc also broke. While no tests were made of the performance of this meter under these conditions, from the

writer's knowledge of it and a thorough examination of the meter both before and after breaking, he is justified in stating that similar results would have been obtained as with the other disc meter. As, therefore, these disc meters have proved themselves capable of delivering considerably more than 50 per cent. in excess of their nominal capacity safely, and, when circumstances call for an even greater delivery, to the point of breaking without very materially reducing the available flow, no hesitancy should be shown in using this type on this account alone.

All other meters were tested to the full extent that the available pressure and apparatus would permit, regardless of any limitations as to capacity placed upon them by the manufacturers, and the tables show the extent to which these tests were carried. In only one meter, beside the two disc meters mentioned, was there any breakage due to the construction of the piston, disc, or vanes, and this was in the Standard meter, where with the curved copper vanes on the shaft, under the maximum discharge of 2 648 gallons per minute, three of the vanes were stripped off. To this point everything held, and as this was in excess of any probable working discharge through a meter of this description, unless placed upon a pipe line larger in size than the meter, it should not operate against it. Since these tests the writer understands that these vanes have been further reinforced so as to withstand these excessive discharges.

The views shown on Plates II and III are sufficiently well explained by their titles, and are of interest simply in giving an eye impression of both the apparatus used and streams discharged.

EFFECT OF METERS UPON FIRE STREAMS.

This question is so broad and has been discussed heretofore in so many of its phases that the writer does not deem it advisable to include it in the scope of this paper.

It is his hope, however, that herein may be found information that will be useful in settling questions always arising as to the performance of large-sized meters, and possibly assist in bringing about improvements therein which will more thoroughly draw together the present opposing ideas of water departments and insurance underwriters. All the manufacturers whose meters were represented in these tests have some time since received



FIG. 1. — DISCHARGE THROUGH CROWN METER AFTER COVER PLATE HAD GIVEN WAY, AND 4-INCH NOZZLE, — 2 128 GALLONS PER MINUTE.



FIG. 2. — DISCHARGE THROUGH HERSEY DISC METER AFTER DISC WAS BROKEN, AND 4-INCH NOZZLE, — 1 218 GALLONS PER MINUTE.

copies of the preliminary results, and numerous suggestions and remarks thereon have been made to the writer. Generally it has been thought advisable not to specifically deal with these, but to leave them for such discussion as the subject may invoke. It has also been the writer's pleasure to have personal conferences with several of them since these results have been known. At one of these informal talks, a gentleman prominently connected with one of the leading meter companies informed the writer that they were already working upon a meter which for fineness of registration would be equal to the best of those shown in these results, while the loss of pressure or retardation would not be in excess of that of the best types of current meters, also herein shown. He was not, however, in position to state with much more definiteness at that time just what the nature of this meter would be, except that it would not be a current meter, as certain details had then to be worked out before further exploiting it. This shows that the manufacturers are alive to the requirements of the situation, and a thorough discussion at this time, both of results obtained and those desired, would be of decided advantage to all concerned.

TABLE No. 1.
RETARDATION, OR LOSS OF PRESSURE, IN SIX-INCH WATER METERS. POUNDS PER SQUARE INCH.

Gallons per Minute Flowing through Meter.	Hersey Rotary.	Crown.	Empire.	Hersey Disc.	Keystone.	Torrent with Fish Trap.	Torrent without Fish Trap.	Union.	Gen.	Standard, Aluminum Paddles.	Standard, Copper Vanes.	Gallons per Minute Flowing through Meter.
50	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50
100	0.5	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	100
150	1.1	0.9	0.7	0.5	0.3	0.2	0.2	0.1	0.1	0.1	0.1	150
200	1.9	1.5	1.3	1.0	0.5	0.3	0.3	0.2	0.2	0.1	0.1	200
250	3.0	2.4	2.1	1.5	0.8	0.5	0.5	0.3	0.3	0.2	0.2	250
300	4.3	3.4	3.0	2.2	1.2	0.8	0.7	0.5	0.4	0.3	0.2	300
350	5.8	4.7	4.0	3.0	1.6	1.1	0.9	0.7	0.5	0.4	0.3	350
400	7.6	6.1	5.3	4.0	2.1	1.4	1.2	0.9	0.6	0.6	0.4	400
450	9.7	7.7	6.7	5.0	2.7	1.7	1.5	1.1	0.8	0.8	0.5	450
500	11.9	9.6	8.2	6.2	3.3	2.2	1.8	1.4	1.0	0.9	0.7	500
550	14.4	11.6	10.0	7.5	4.0	2.6	2.2	1.7	1.2	1.1	0.8	550
600	17.2	13.8	11.9	8.9	4.8	3.1	2.7	2.0	1.4	1.3	1.0	600
650	20.2	16.2	13.9	10.5	5.6	3.7	3.1	2.3	1.7	1.6	1.1	650
700	23.4	18.7	16.2	12.1	6.6	4.2	3.6	2.7	2.0	1.8	1.3	700
750	26.9	21.5	18.6	13.9	7.5	4.9	4.2	3.1	2.2	2.1	1.5	750
800	30.6	24.5	21.1	15.8	8.6	5.5	4.7	3.6	2.5	2.4	1.7	800
850	34.5	27.6	23.9	17.9	9.7	6.3	5.4	4.0	2.9	2.7	1.9	850
900	38.7	31.0	26.7	20.1	10.8	7.0	6.0	4.5	3.2	3.0	2.2	900
950	43.1	34.5	29.8	22.3	12.1	7.8	6.7	5.0	3.6	3.4	2.4	950
1 000	47.8	38.2	33.2	24.8	13.4	8.7	7.4	5.6	4.0	3.7	2.7	1 000

1 050	52.7	42.2	36.4	27.3	14.7	9.5	8.2	6.1	4.4	4.1	3.0	1 050
1 100	57.8	46.3	39.9	30.0	16.2	10.5	9.0	6.7	4.8	4.5	3.2	1 100
1 150	63.2	50.6	43.7	32.8	17.7	11.5	9.8	7.4	5.3	4.9	3.6	1 150
1 200	68.9	55.1	47.5	35.7	19.3	12.5	10.7	8.0	5.7	5.4	3.9	1 200
1 250		59.8	51.6	38.7	20.9	13.5	11.6	8.7	6.2	5.8	4.2	1 250
1 300		64.7	55.8	41.9	22.6	14.6	12.5	9.4	6.7	6.3	4.6	1 300
1 350		69.7	60.2	45.1	24.4	15.8	13.5	10.1	7.3	6.8	4.9	1 350
1 400		75.0	64.7	48.5	26.2	17.0	14.5	10.9	7.8	7.3	5.3	1 400
1 450				52.1	28.1	18.2	15.6	11.7	8.4	7.9	5.7	1 450
1 500					30.1	19.5	16.7	12.5	9.0	8.4	6.1	1 500
1 550					32.1	20.8	17.8	13.4	9.6	9.0	6.5	1 550
1 600						22.2	19.0	14.3	10.2	9.6	6.9	1 600
1 650						23.6	20.2	15.2	10.8	10.2	7.3	1 650
1 700						25.0	21.4	16.1	11.5	10.8	7.8	1 700
1 750						26.5	22.7	17.1	12.2	11.5	8.2	1 750
1 800						28.1	24.0	18.0	12.9	12.1	8.7	1 800
1 850						29.6	25.4	19.1	13.6	12.8	9.2	1 850
1 900						31.3	26.8	20.1	14.4	13.5	9.7	1 900
1 950						32.9	28.2	21.2	15.1	14.2	10.2	1 950
2 000						34.6	29.6	22.3	15.9	15.0	10.8	2 000
2 050						36.4	31.1	23.4	16.7	15.7	11.3	2 050
2 100						38.2	32.7	24.6	17.6	16.5	11.9	2 100
2 150						40.0	34.3	25.7	18.4	17.3	12.5	2 150
2 200							35.9	27.0	19.3	18.1	13.0	2 200
2 250							37.5	28.2	20.2	19.0	13.6	2 250
2 300								29.5	21.1	19.8	14.3	2 300
2 350								30.7	22.0	20.7	14.9	2 350
2 400									22.9	21.6	15.5	2 400
2 450									23.9	22.5	16.2	2 450
2 500									24.9	23.4	16.8	2 500

TABLE No. 2.
SENSITIVENESS OF SIX-INCH WATER METERS IN THE REGISTRATION OF SMALL FLOWS.

METER.	½-INCH OPENING.				¾-INCH OPENING.				1-INCH OPENING.			
	Gallons per minute.		Unrecorded Flow.		Gallons per Minute.		Unrecorded Flow.		Gallons per Minute.		Unrecorded Flow.	
	By Weight.	By Meter.	Gallons.	Per Cent.	By Weight.	By Meter.	Gallons.	Per Cent.	By Weight.	By Meter.	Gallons.	Per Cent.
Crown	39.35	38.70	0.65	1.3	25.12	24.86	0.26	1.0	11.68	11.34	0.34	2.9
Hersey Disc	38.21	38.98	+0.77	+2.0	24.73	24.13	0.60	2.4	11.61	11.33	0.28	2.5
Empire	40.09	39.03	1.06	2.7	24.34	23.62	0.72	3.0	11.62	11.46	0.16	1.4
Keystone	38.77	34.64	4.13	10.7	24.86	22.88	1.98	8.0	11.66	10.64	1.08	9.3
Union	38.38	37.56	0.82	2.1	25.05	22.78	2.27	9.0	11.66	8.36	3.30	28.3
Gem	38.28	37.56	0.73	1.9	22.93	20.49	2.44	10.6	11.42	5.69	5.73	50.2
Torrent	38.59	36.93	1.65	4.3	24.97	23.09	1.88	7.6	11.58	6.03	5.55	47.9
Hersey Rotary	38.08	36.52	1.56	4.1	25.14	20.43	4.71	18.7				
Standard	38.18	24.26	13.92	36.5								

TABLE No. 3.

ACCURACY OF SIX-INCH METERS ON LARGE FLOWS, AS DETERMINED BY NOZZLE DISCHARGES; SHOWING MINIMUM AND MAXIMUM RATES OF FLOW FOR EACH NOZZLE, AND PER CENT. OF METER DISCHARGE TO NOZZLE DISCHARGE.

METER.	½-INCH NOZZLE.		1-INCH NOZZLE.		1½-INCH NOZZLE.		2-INCH NOZZLE.		2½-INCH NOZZLE.		4-INCH NOZZLE.		AVERAGE PER CENT. ALL NOZZLES, GIVING EACH EQUAL WEIGHT.
	Gallons per Minute.	Per Cent.	Gallons per Minute.	Per Cent.	Gallons per Minute.	Per Cent.	Gallons per Minute.	Per Cent.	Gallons per Minute.	Per Cent.	Gallons per Minute.	Per Cent.	
Hersey Rotary	67	98.6	278	100.7	408 to 537	99.5	580 to 807	99.7	805 to 965	99.9	1 195	100.1	99.7
Crown	67	99.2	215 to 280	99.6	434 to 550	97.3	606 to 817	95.9	868 to 944	97.4	1 409	87.3	96.1
Empire	67	99.5	282	99.9	440 to 554	98.3	655 to 806	99.4	950 to 1 092	100.9	1 350 to 1 420	97.2	99.2
Hersey Disc	67	100.7	283	99.5	412 to 561	99.3	626 to 894	100.7	945 to 1 145	102.8	1 217 to 1 455	99.7	100.4
Keystone	67	100.0	284	101.6	574	100.0	787 to 953	101.3	1 065 to 1 301	102.8	1 518		101.1
Torrent	67	101.8	285	102.4	446 to 582	100.3	789 to 982	103.4	1 063 to 1 379	104.5	1 474 to 2 220	99.6	102.0
Union	67	98.6	285	100.9	583	99.3	850 to 996	100.2	1 193 to 1 378	101.2	1 730 to 2 341	96.8	99.5
Gem	67	99.7	286	98.6	587	97.7	848 to 1 004	99.2	1 198 to 1 430	100.4	1 753 to 2 506	97.9	98.9

TABLE No. 4.

APPROXIMATE NUMBER OF FEET OF ORDINARY STRAIGHT CLEAN CAST-IRON PIPE THAT WOULD CAUSE THE SAME RETARDATION OR LOSS OF PRESSURE AS THE METERS, UNDER A FLOW OF 500 GALLONS PER MINUTE, BEING A VELOCITY OF 5.67 FEET PER SECOND.

METER.	FEET OF PIPE.
Hersey Rotary	1 340
Crown	1 070
Empire	920
Hersey Disc	690
Keystone	370
Torrent, with Fish Trap	240
Torrent, without Fish Trap	210
Union	160
Gem	110
Standard, Aluminum Paddles	100
Standard, Copper Vanes	80

CONCLUSION.

While these tests were made under the immediate direction of the writer, at no time during the eighteen days they were in progress was he without the advice and assistance of other gentlemen well qualified to coöperate in work of this description. The meter manufacturers were represented by Mr. D. A. Munroe, Superintendent of the Pittsburg Meter Company, and Mr. J. A. Tilden, General Manager of the Hersey Manufacturing Company. Mr. A. W. Hardy and Mr. Sanderson, Inspectors of Automatic Sprinkler Risks of various stock insurance companies operating in the central and southern sections of the country, and Mr. C. H. Smith, Inspector for the Factory Mutual Fire Insurance Companies of Boston, represented the underwriters' interests; while Mr. F. H. Crandall, of Burlington, Vt., who needs no introduction to you, was sufficiently interested in these tests to come to Tennessee and spend ten days with us. It can therefore be said that in no sense were these experiments *ex parte*. In addition to the personal presence of these gentlemen we were largely assisted by the advice, both personal and by letter, of Mr. E. V. French, of the Factory Mutuals, who has had large experience in this class of experimental work, and also by the loan of apparatus both by the

Factory Mutual Companies and by the Hersey Manufacturing Company. To all these parties, to the meter companies who so kindly furnished meters for these tests, to Messrs. John A. Durham and Wellington Donaldson of the local force of the Knoxville Water Company, who materially assisted in this work, and particularly to Gen. Elbert Wheeler, Treasurer of the Knoxville Water Company, both for permission to use results obtained and valuable assistance in compiling the same, the writer desires to express his full appreciation.

DISCUSSION.

MR. F. H. CRANDALL.* *Mr. President and Gentlemen of the Association*, — It was my privilege to be present during a large part of the work which was done by Mr. Kimball at Knoxville, and I regret as much as any of you that Mr. Kimball was not able to be here to read his paper and to talk about it himself. The Knoxville Water Company, being a private company, is perhaps a little more interested, or appreciates the suggestion in regard to furnishing water for nothing for private fire pipes more keenly than public corporations do; and they have been to a very considerable expense in preparing for and doing the work of ascertaining what the efficiency and what the effect of the different classes of meters at present on the market would be upon the fire service. The general idea seemed to be that some accident would happen to almost any meter when it was called upon to deliver a large quantity of water, and that the result would be disastrous. I think it has been plainly shown that that opinion is erroneous. It has been shown at Knoxville, outside of these tests, that a by-pass can be opened if necessity calls for its being opened. The water company employs a man whose duty it is to be present at every fire. There were several fires while I was there, and about the first man I saw at the fire — and I got there among the first — was the man from the water works; and if there had been occasion for the opening of a by-pass I am perfectly satisfied he would have got it open.

The blocking of the different meters that were blocked was done in such an effective manner as never would have happened accidentally. A Crown meter, for instance, never could have been stopped up in the way the Crown meter was stopped up in the

* Superintendent of Water Works, Burlington, Vt.

test. There were two pieces of 2 by 4 joist placed inside the meter on opposite sides of the float, so that it was absolutely prevented from moving. When the difference in pressure became sufficient to overcome the strength of the screws in the division plate, the division plate gave way, and the discharge of the meter increased 50 per cent., as you see by the tables. The disc meter, which was injured also, increased its discharge after injury.

The insurance people, particularly the Factory Mutual people, joined with Mr. Kimball in the attempt to ascertain the facts in regard to these meters, loaned him material, and had a representative on the ground for a considerable length of time, and appeared in every way to be interested in a satisfactory solution of the question. The insurance people naturally want to make assurance doubly sure and take a bond of fate. The water-works people want to have absolutely good assurance that they will not be defrauded by the use of services over which there is no control. The devices or meters which were tested, as you can see from the published results, do not record the very finest flows. Those that do probably will not record them for any great length of time after they have been worn in service, and those that are the most accurate in the measurement of water afford the greatest obstruction to the flow. There are at present two devices which I know of, and I believe that there are more in process of construction, by which it is hoped to overcome, to a considerably greater degree, the objections to meters at present on the market.

MR. J. A. TILDEN.* Mr. President, it was my pleasure to be present at Knoxville during the last few days of the meter tests which form the subject of the paper which has just been read. I think that the water meter companies, as well as our water-works friends, are very much indebted to the Knoxville Water Company, to Mr. Wheeler, and to Mr. Kimball in particular, for the efficient manner and for the careful manner in which these tests were carried out. In a sense one might say that these tests were competitive or comparative, and from that point of view they are of special interest to the meter manufacturers. We had opportunities at Knoxville for the use of a very large amount of water; that is, we had a 6-inch pipe leading directly from a 14-inch main at 80 pounds pressure, or thereabouts, and dis-

* Hersey Mfg. Co., South Boston, Mass.

charging directly into the river without any elbows or curves, giving us in that way a very much larger amount of water and at a greater head than any of us have in our factories; and we had, therefore, an opportunity for comparison which I think has never before been presented.

I think all meter companies should welcome comparative tests of this kind. We all want to know what our meters will do, and we want to know what they will do in comparison with those of other manufacturers; then it remains for our water-works friends to decide. I think we all, both manufacturers and water-works people, are very glad to have these tables showing these comparisons, and we appreciate them from the fact that it takes time and it takes money to go through a series of tests of this kind. The Knoxville Water Company put in a good deal of time and not a little expense; the meter companies, as Mr. Kimball has said, loaned the meters and the apparatus.

I am very glad to note that as the result of the tests, or as one of the outcomes of the test, one of our New England water works, namely, that at Burlington, Vt., of which Mr. Crandall is superintendent, is preparing to test on a scale as elaborate as that at Knoxville. Many of you have apparatus for testing meters which is more or less elaborate, but ordinarily it is of somewhat limited capacity, that is, of a capacity only suitable for testing small meters. There are very few places in the country where meters can be tested at the rate at which they were tested in Knoxville. You will observe they got discharges there as high as 3 000 gallons a minute, and Mr. Crandall will have an opportunity to put through the same amount. The outcome of a movement in this direction, that is, toward the testing of large meters on an extensive scale, will be to put in the hands of water-works people valuable information, and it will also be a very good lesson for the meter companies. The result will be the improvement of meters for some of the particular services for which these large meters are wanted, that is, for large manufacturing establishments for fire protection, for the supplies of smaller cities and towns by larger ones, for hydraulic elevators, and the like.

The purpose of my remarks is simply to show that this is a step in the right direction, valuable alike to the water departments

and to the manufacturers of water meters. I thank you very much for the opportunity to say these few words.

MR. FRANK C. KIMBALL (*by letter, November 27, 1903*). Since the preparation of my paper we have had opportunity to observe the practical effect of meters upon fire streams here at Knoxville. A woodworking establishment, situated about two miles outside of town, has an equipment of automatic sprinklers with two fire hydrants connected with the supplying pipes in the yard of the mill. The installation is fed through a 6-inch pipe, metered by a 6-inch Crown meter in bypass, with indicator post gate in main line, in exact accordance with the " sketch of standard metered fire connection," as shown on p. 219 of Vol. 16 of the JOURNAL of this Association. This connection at the present time is also at the end of a line of pipe consisting of about 1 300 feet of 6-inch pipe and 300 feet of 8-inch pipe connecting with a 10-inch main, all of which was laid for this particular factory, so that the conditions as to friction loss under heavy discharges are not as good as might be desired or as they may be later when this 6-inch line is completed by a circuit. Beyond this meter the pipe is tapped, and boiler and other supplies for the mill are taken, so that this 6-inch meter controls all uses for this purpose. In adjoining premises is a mattress factory, and among the buildings comprising the same was a warehouse for storing excelsior. These premises had no fire protection, the excelsior storehouse being between 200 and 300 feet from the nearest hydrant in the premises supplied. A fire started one afternoon recently in this excelsior warehouse, and was well under way before being discovered; this warehouse was of wooden construction. Two 2½-inch fire streams were taken off the nearer of the two hydrants by the employees of these two establishments, and while, from the nature of the building and its contents, very little of these were saved, all the surrounding buildings, as well as piles of lumber stacked in the yards for drying purposes, were kept from burning or even scorching to any appreciable extent. Being outside the corporate limits of the city, no alarm was sent in, but the water company was notified; and as quickly as possible, as usual, one of its employees was on the ground, when it was found that the sealed gate had not been opened. Investigating the reason, it was found that the engineer of the protected establish-

ment, who had charge of the mill's fire brigade, while having this bypass gate thoroughly in mind, even to the extent of going to it and seeing that it was ready to operate with wrench, etc., concluded that he would like to see how these streams would work through a meter, and therefore did not open the gate; and his statement as to the effect of these streams was, that after seeing the way they worked, he did not dare to open the gate, as his men would not have been able to control the streams if the pressure had been any greater. As it was, the force of the stream was sufficient, after an entrance into the sides of the building by axes had been made, to thoroughly tear off the boarding and scatter the contents of the warehouse. The pressure at this point is ordinarily about 100 pounds per square inch, and the engineer states that at no time during the fire did his water pressure gage in the engine room show less than, as he put it, from 75 to 80 pounds, which, taking into consideration the long length of pipe, as well as the obstruction offered by the bypass and meter, cannot but be regarded as an excellent result.

I think Mr. Crandall's idea that meters in the 6-inch size will not record small or fine flows for any great length of time after they have been in service is not wholly borne out by facts, except perhaps as drawn from his experience with smaller meters. While undoubtedly water of a gritty nature, or having foreign matter in suspension, will have an influence upon the wearing parts of meters, large as well as small, our experience here with filtered water shows very little trouble along these lines. Since the fire above mentioned, that particular meter has been tested for accuracy, and its unrecorded flow was less than half a gallon per minute on all streams except with 1-16 inch opening, where it was about three-quarters of a gallon per minute, showing that the use it had been put to had not materially affected its sensitiveness. This meter was set in November, 1901, and to date has registered about 520 000 cubic feet. As an example of how a meter set as this one is can be tested at comparatively small expense, and without removing it from its place, it may be of interest to the Association to know that this was done in six or eight hours' time when the factory was not running, first seeing that all outlets were closed and that the meter did not register or move for some considerable period, thus showing that the piping was

all tight and no unaccounted for water passing through the meter. A $\frac{3}{4}$ -inch meter, which had previously been calibrated, was then attached to a convenient pipe in the boiler room, and various, sized streams, from $\frac{3}{4}$ inch down, were run through this meter, and the readings of the small meter, after corrections, were compared with the larger meter, and the above results obtained. Between observations some considerable time was allowed to elapse, during which the larger meter was carefully observed to see if in the meanwhile any water was passing through it, and the result in all cases being negative, I think we can safely rely upon the results shown. This to me at least shows that for the limited time and quantity used by this meter, including one fairly good fire test, it has lost none of its accuracy. I think if water-works managers, in places where large meters are set, would, from time to time, have them tested in some such comparatively inexpensive way, and at the same time give us the benefit of such experience as they may have in regard to large uses of water through such meters for fire or other purposes, that it would be of very great interest to this Association as showing in practice, as well as in tests, what large-sized meters are capable of doing.

I have been pleased to learn that the Water Department at Burlington, Vt., has taken the initiative in New England in establishing a permanent testing plant for large meters or devices requiring a large supply of water, to properly demonstrate their ability and capacity. I have also followed by correspondence the tests made upon an automatic regulating gate to be used in place of a manually operated gate upon fire services, and believe these are all steps in the right direction toward obtaining and maintaining that degree of protection and inspection to water departments that is so essential to the proper conduct of their business, and cannot but believe that all these experiments and determinations will result in producing and perfecting controlling devices and registering apparatus in the shape of meters or otherwise that will, and very shortly, bring water departments and insurance underwriters upon a common ground, to the mutual advantage of both. I am also glad to note in Mr. Tilden's remarks that meter manufacturers are in line and sympathy with this movement to thoroughly test meters on a large scale, as it

shows their desire, already known to the writer, to give to water departments the best that their experience and ability can produce, and the only result possible from this hearty co-operation of all concerned will be to bring about results in which every one can but have confidence.

THE RECIPROCAL OBLIGATIONS OF THE MANAGEMENT OF A WATER SUPPLY SYSTEM AND THE COMMUNITY.

BY JOHN O. HALL, EX-MAYOR, QUINCY, MASS.

[*Read September 10, 1903.*]

Many students of political economy believe that the problems of the cities are those which most affect the progress of the race; that the forces which are potent in the cities of the land are those which make or mar the nation. Certain it is that all who become in any way familiar with governments of large communities realize that there are many powerful influences at all times in operation in these governments which will work dire disaster to those communities and so to the state and the nation unless they are checked in their activities and as much as possible forced out of immediate operation and driven into the background.

To any one connected with the government of one of the larger or smaller cities of the land who seeks to administer his office on the broad lines of strict business principles and with an eye single to the best interests of the community, there opens a pathway beset with a multitude of problems difficult of solution and hedged about with numerous forces and interests antagonistic to those lines and very active and belligerent in their opposition.

The problems which beset the governments of large communities are becoming at the present time very complex, and the tendency is to decide them, in very many cases, on the policy of a temporary expediency or political advantage, rather than on their merits and for the welfare of the community.

Of the many departments of municipal governments, none contains more perplexing problems than the water department, and in what I shall say on the subject in hand, I shall endeavor to treat these problems on the line of an honest attempt to administer this department for the public welfare, regardless of personal advantage or political policies.

My experience has taught me that the line of economy and the public welfare is the true one for the best results. The axiom

that "honesty is the best policy" most certainly holds true in the administration of public affairs, for however much we may seem to secure by an abandonment of what we acknowledge to be an honest course in any given question, in the end those who abandon such a course are sure to meet disaster, and the community of innocent citizens must pay the added cost.

The policy of nearly every government of a large community at the present day is too much in the line of unwise extravagance, and is a departure from sound business principles and honest effort for the public good.

The rapid growth of American cities and the requirements of modern civilization make the demand for a sufficient and efficient water supply more and more serious with each succeeding year, and the duty of the governments of cities to provide and administer such a supply becomes more and more onerous.

To secure and administer such a supply for only the purely domestic uses is quite simple, but by reason of the rapid growth of population, crowding large numbers into a comparatively small district, the necessity arises for providing a system of sewerage, and this very largely increases the draft on the water supply. Further, by reason of this crowding of people, the added demand exists for a source of supply remote from the dense population, in order, as much as possible, to avoid contamination by impurities which would be detrimental to the public health.

Added to this is the demand for water for the extinguishment of fire. From a comparatively simple acquirement which would allow pure water to flow into the houses of the citizens, we are forced to the consideration of the more extended and complex one of providing an abundant supply with a sufficient pressure to enable the fire department to cope with possible conflagrations. To meet these demands requires the still further and very large expense of pumping and storing at high elevations.

Under the teachings of our present civilization, the obligation rests upon governments to make this supply pure and ample for all purposes, for it is conducive to the welfare of the community, whether we consider that welfare from the point of health, education, or the beauty of surroundings; and it should be furnished wherever desired by the citizens, regardless of the immediate revenue which may be returned in the form of water rates.

We may divide the purposes for which governments of communities are under obligation to those communities to supply water into the following:

1. Domestic uses: *i. e.*, purely for household economy.
2. Sewerage: bath and toilet facilities.
3. Fire extinguishment.

The uses of water may be classed as public and private, and may be divided as follows:

Domestic and Sewerage. — Private: Within the building and upon the grounds of houses, hotels, factories, laundries, and livery stables. Public: Public buildings, fountains, public lavatories, street drinking fountains, street sprinkling, and public baths.

Fire Extinguishment. — Public and private.

Loss. — Leakage: In the system. Waste: By the takers.

The uses of water may further be classed as domestic and financial, and we have:

Domestic. — Private houses and grounds, hotels and apartment houses, street drinking fountains, public buildings, fountains, lavatories, and baths.

Financial. — Factories, laundries, livery stables, street watering, public and private fire extinguishment.

If the supply of water for any given system was unlimited and sure to be in excess of any demand that would be made upon it, we might eliminate the item of loss from our consideration; but unfortunately that is not the case. Water is not free, but, on the contrary, can only be secured at a large cost; and therefore the obligation rests upon every board of management of a water-supply system, every superintendent or water commissioner, to so carefully watch the distribution pipes that the loss of water in the system is reduced to the minimum and that the waste by the takers upon their premises is paid for.

Waste or leakage from the system before the water reaches the consumer must attach to the responsibility of the administration of the water department, and must become a part of the expense and be included in the general tax; waste or leakage on the premises of the consumer is his responsibility and for it he should pay. The private taker should not attempt to place the responsibility of detecting his carelessness or dishonesty upon the government of his city.

The obligation therefore rests to-day upon every community to furnish itself with a supply of water, and upon its government is imposed the duty of administering that obligation; and this implies the proper introduction and distribution of the supply and the just and equitable apportionment of the expense upon the community. This obligation may be discharged by a community establishing its individual plant, or by combining with one or more communities in such establishment, or by taking advantage of a system established by private capital. I shall speak upon this subject primarily from the point of supply under the control of a community, but much that relates to a community supply will apply equally to one under private ownership and control.

In the methods of administration in Massachusetts, and I think in most if not all of the communities represented in the New England Water Works Association, the water department stands as a separate item in the community expense in this regard, that while the community credit is pledged for the establishment of the plant, the revenue for the redemption of that debt and for the interest and maintenance comes alone from the water takers. This I believe to be wrong in principle and to be unfair to the general citizen.

The introduction and distribution of water, like every other department of the public service, is for the general welfare, and therefore the expense attending upon such establishment should be borne by the real and personal property of the community and should appear in the general tax.

Water has ceased to be a convenience or a luxury, but has become an essential department of municipal affairs. Neighbors have crowded in upon the individual, forcing him to abandon his well, and therefore all should share in the expense of the substitution of another supply. For this reason the contention at law that a difference exists between the water department and the other departments of municipal administration, and that the water service exists as a business enterprise and is outside the pale of the rights and privileges appertaining to the other departments which are claimed to exist for the safety and convenience of the public, I believe to be wrong.

The expense incurred in the establishment of the water sys-

tem — which should include the cost of preliminary surveys and incidental expenses, cost of construction of main aqueduct, dam, reservoir, standpipe, and pumping station, the lines of distribution through the community and hydrant connections — should all be borne by the community and appear in the general tax each year in the annual provision for the maturing debt and interest.

The maintenance of the system, which includes the cost of water furnished and the cost of connections with real estate, should be borne by the individual takers.

It is admitted that there is nothing unfair in this apportionment, for the entire holdings of the community are benefited by the existence of an efficient water system and therefore should of right bear their proportion of the expense. The force of this claim is recognized by many officials, as is evidenced by the practice of charging an additional rate based on the valuation of the property.

As it is at present, the water taker is taxed for municipal purposes and in addition must pay as large a water tax as he will bear; and the excess of income over water expenses is diverted to additional and in many cases needless and extravagant schemes for the illegal expenditures of public money. As an evidence of this fact, note, in every report of the water departments of our communities, the transfers from water receipts to various foreign departments of the public service; to quote one case, a transfer of $23\frac{1}{2}$ per cent.; and another of 32 per cent. of the original appropriation. These transfers show in almost every municipal report, and are violations of law and of great injustice to water takers.

As under the present custom the water expenses are paid entirely by the water takers, any excess of revenue over expenses should be returned to them in the form of reduced rates.

There should be a fair return for the commodity delivered. This, where the water is furnished by the community, should be only the cost of the water; but where a community chooses to disregard its duty and fails to furnish a supply itself, it must bear the added cost of a profit, larger or smaller, to the private company which takes the risk and management of a supply. Private enterprise will see and avail itself of such an opportunity.

and the community must pay the penalty of its neglect either in increased rates or imperfect construction; or finally a very large purchase price, with the consequent large expenses of litigation.

On the idea of putting the cost of the establishment of the water system and the water used for public purposes into the general tax. I will quote from the report of the special committee of business men of Madison, Wis., appointed to consider this matter of water rates and water charges, as follows:

"It will be conceded, we think, that this public use should be charged on the community, not in proportion to the amount of water used for other purposes, but more in proportion to property interests.

"Some cities attempt to distribute or equalize this charge on the community by crediting the water fund with a reasonable amount for each fire hydrant, and for water used by various departments of the city government, school boards, park boards, street sprinkling, etc., and by a system of bookkeeping methods crediting back into the general fund any surplus of earnings thus obtained, but this committee is of the opinion that the cost of water for various public uses should be met by general taxation."

And again from the same committee's report:

"The practice of this department has been, and is, to pay from the water fund the cost of laying all water mains, service connections, cost of meters, etc. Possibly something might be said in favor of assessing these expenses to abutting property, the same as street improvements and sewers are assessed."

If, then, we put the cost of the establishment of the system into the general tax levy, thus taking care of the annually maturing debt and interest, we have left only the maintenance of the system and house connections to be charged to the water takers.

In the case of a number of communities joining in an extensive water supply system under the conduct of the state, as is the case of the Metropolitan Water System of Massachusetts, the amount assessed upon the several communities in that district would be divided into the amount needed for the annually maturing expense of construction and the amount needed for the annual maintenance. The several governments would then put one item into their tax levies and the other into the amount for maintenance to be charged to the water takers. With this

arrangement you have definite figures to consider, for the cost of construction to a given date is shown in dollars and cents, and the annual appropriation gives the amount to be charged to the water consumers.

If you eliminate the large items of debt and interest and extensions you simplify the question of rates to a very large extent. Accepting this method, you include in the annual appropriations for the various departments sums sufficient to pay for the water actually used, and this annual appropriation goes into the amount of the tax levy.

The cost of maintenance is something which can be determined, — so many gallons furnished at so much cost gives the cost per gallon, — and the number of gallons used by any taker determines the amount which he is to pay.

If the calculation of the price per gallon proves to be erroneous and an excessive revenue is collected, the taker should have the benefit in a reduced rate. This change of rate need not be made every year, but could be made after the experience of two or three years should give a reasonably accurate basis of calculation.

If it is possible to determine the amount of water used in the extinguishment of fires, I think this amount should go into the tax levy under the appropriation for fire department; but I am firmly of the opinion that the idea of crediting the water income with the sum arrived at by multiplying the number of hydrants existing in any community by a fixed number of dollars is not a good one and should not be adopted, or if it has been adopted should be abandoned.

Basing the water rate on the cost per gallon multiplied by the number of gallons requires the use of the meter for purposes of measurement; but I think it is generally conceded that to measure water is the only proper method of determining the rate of payment by the water taker. Everything else that we use we buy by weight or measure, whether it be merchandise, clothing, food, gas, or electricity; and why should the quantity of water we use be guessed at?

A certain sum should be appropriated for the installation of meters each year, and this should be included in the expense of maintenance to be apportioned upon the water takers. The

cost of the installation of the meters upon any property should be a lien upon that property, and the city should charge for the actual water which the meter records as passing through it, the charge to be made to the owner of the property and not to the tenant. The owner of the property must settle with his tenant.

The meter should be the property of the city, and the expense of examination should be included in the annual appropriation for maintenance. The charge should be for actual water passing through and be so much per gallon, without any minimum price, or one price for the first thousand gallons and another price for succeeding gallons.

On the question of fire protection in the community we come to the one item in the whole department which causes the most discussion and gives rise to the most conflicting differences of opinion.

Fire protection, because of certain established methods in cases of large manufacturing plants, is divided into what I have called public and private.

While there is a certain element of sentiment in connection with fire extinguishment in that the citizen's home is protected and his household goods are not destroyed, and therefore community governments are exercising their true paternal function in this regard, I am of the opinion that this claim has very little weight indeed and that the question is purely a business and financial one, both as to public and private service.

Under our modern adjustments we find ourselves confronted with two conditions, a demand for an extensive system for the extinguishment of fire in general, and also one sufficient to meet the added demands of a provision for private protection of property by an elaborate system of standpipes and laterals which require to be kept constantly full of water under sufficient pressure to carry to the highest part of the building. As I have stated, and as is generally admitted, the provision for fire extinguishment adds very materially to the expense of the establishment and maintenance of a water plant, and in a large community the provision for private fire extinguishment still further largely increases the cost. If this cost is covered into the tax levy and all interests in the community bear their proportion, the private citizen and the business plant, the wealthy land owner and the

humblest poll-tax payer, the claim of any one that he is entitled to receive something from the community from the fact that he is a part of that community is answered; he receives certain things for which he is entitled and he pays for it in his contribution to the expenses of the community.

Just here the community right and privilege ends; beyond this we enter upon the domain of the individual.

The individual pays for what he uses and only for what he uses at what it costs the community to furnish it to him.

It is a mistaken idea that water is free when you consider it from the idea of the needs of a community. Water in its existence is free, and ample in its supply, take the world over; but its presence is not universal, and to bring it to the barren waste makes it an article of merchandise, and as an article of merchandise, under strict business laws, it must be bought and sold.

I can see no ground upon which to establish a just claim upon any system of water supply to furnish water free for such an enterprise as a business plant. The owners of such an establishment pay for everything else which they use, and why should the community in which they are located furnish its goods free of charge? To the argument that such an enterprise may be of great advantage to the community in which it is located, I answer, that claim rests on the sentimental idea of government to which I have alluded and should have very little weight. In fact, a concession to any private enterprise by which the public expense is increased is illegal, and any tax rate based upon an action of this kind by a community would be vitiated and could be declared invalid.

If the water supply was furnished to the community by a private company, the contention of a public benefit certainly would not hold.

The establishment is benefited with others of the community by the existence of a strong fire department, receiving its benefit in dollars and cents and paying for it with others in its municipal tax; it is alone benefited, financially, in its system of piping, in which the community has no interest or profit, and therefore should not be called upon to bear any portion of the expense. The purpose for, which this private protection is established is to limit to the minimum any loss of profit by an interruption of

the business because of fire. This is entirely a personal and selfish interest, and therefore the public should not be called upon to bear any portion of the expense. To the suggestion that an interruption to the business would be a loss to the community, I answer that while this may be true I cannot see that it is any reason for allowing a constant premium to the individual in the way of free water for a series of years, at the expense of the community, in exchange for such a contingency.

The concession might with justice be made that when the piping system was established it should be filled by the department on the ground that the water simply stands in the pipes and is not therefore a constant demand upon the system and consequently not a cost to the community. The private company saves in insurance charges by a well-equipped fire department and the piping system. This saving is all its own.

For this former benefit he pays his proportion with all the other values of the community, and for the latter expense he secures all the benefit, which is perfectly proper.

The insurance companies receive the benefit of the well-equipped fire department for which the citizens tax themselves, and also the benefit of the protection afforded by systems of piping, and therefore I do not see where they enter into the consideration at all.

It is unjust to the citizens of a community to claim that the officials of a water system should be obliged to be detectives to make sure that the piping systems are in good condition and that no use is made of them other than for fire extinguishment. Evidencies of an improper use of these systems of piping, and defects in construction and condition, are frequent and ample, and the individual is wronging the community when he obliges it to go to the expense of detecting these defects. If a group of manufacturing companies should combine to put in a plant for their collective use, it is certain that all these points would be most carefully watched to see that each individual plant was in first-rate condition and that no one concern obtained any advantage at the expense of others in the group. Surely the community is entitled to as fair treatment as a combination of mercantile interests.

Thus far I have considered the subject from the point of view

of a public or community control, but where the supply is furnished by a private company most of what I have said still holds true. The principal difference is that while I claim that under the community control the citizen should have his service at cost, in the case of the private company no such contention can be maintained. The principles remain the same; the details of the relation between the company and the community differ.

The relations between company and community are in the way of franchises for rights through its streets and ways, and compensation for public purposes and for fire department service.

For the private citizen the burden falls more heavily under a system of private control than under a municipally controlled one, for under the former management maturing debt, interest, depreciation, maintenance, including salaries and repairs, together with extensions, must all be assessed upon the water takers, and to this sum must be added a profit for the stockholders.

Water used in the public service would in this case be paid for in the tax levy and the individual service paid direct to the company. Under both forms of administration, however, the basis of cost and quantity used should fix the rate of collection. In all cases the meter is the proper measure of quantity, and the cost per gallon, including all the items heretofore enumerated, the unit of value.

I am aware that the method which I have outlined, of including all except the maintenance in the tax levy, is at variance with the general practice; yet I think it is the fair and just method, for as at present administered the water taker pays more than his proportion of the expense, as the large holder of real estate made very much more valuable by reason of the water system does not pay any portion, but the water taker pays all and in addition contributes to the various schemes for general municipal expenditure beyond the amounts allowed by law. I believe it to be the bounden duty of all connected with the administration of public affairs to use every effort to have the administration of systems of water supply improved along these lines.

PUMPING BY ELECTRICITY.

BY F. H. PITCHER, C.E., CHIEF ENGINEER, MONTREAL WATER AND POWER COMPANY.

[Read September 10, 1903.]

The rather high-sounding title of this paper is not to be taken as a fair indication of its scope. At the outset, in order to clear the author, it should be stated that it was none of his doings. Mr. Kent, our genial secretary, mildly suggested to the writer, on meeting him in the city last July, that a paper on some subject connected with water works in this district would be acceptable to the Association at its convention in Montreal. It was mentioned, by an unhappy chance, that there were some large electric pumps operating in connection with the water supply of the outlying municipalities of this city with which the writer was interested. Forthwith a few days later an innocent-looking letter arrived, making the author responsible to the convention for a paper on this large field of engineering. Such few observations as may be presented here will, it is hoped, be of some interest to the members; but they cannot and do not aspire to cover the range indicated by the title.

Our larger cities in the East, like Montreal, Toronto, Hamilton, Ottawa, Quebec, etc., are more favorably situated perhaps for obtaining cheap electric power than corresponding cities in the New England States and others along the Atlantic seaboard. This is on account of their proximity to large water powers, capable of commercial development. None of these cities is, everything considered, in a better position in this respect than Montreal. Its population, manufacturing and kindred industries offer a ready market for a larger amount of power, while its proximity to the developed and undeveloped powers on the Richelieu, St. Lawrence, Ottawa, and Shawinigan rivers makes it possible to supply the demand on a commercial basis.

The following are the principal developed water powers deliv-

ering under normal conditions of operation power to Montreal approximately as follows:

At Chambly, Que., 21 miles from city,	20 000 H. P.
At Lachine Rapids, Que., 5 miles from city,	14 000 „ „
At Shawinigan Falls, Que., 80 miles from city,	6 000 „ „

The latter is a 30,000 horse-power development. The remainder of the power is being absorbed now by the industries at Shawinigan Falls, or will, in all probability, shortly be taken up by this city as well as by other towns and cities along the line.

All of these powers are capable of expansion, and are even now being extended so that there is little doubt that twice the present amount of electric power from water powers will be available in Montreal in the near future.

The principal undeveloped powers near the city are:

Back River, 6 miles from city,	50 000 H. P.
Soulanges Canal, 30 miles from city,	25 000 „ „

Another important available water power of 50 000 horse power has been developed at Massena, N. Y., approximately sixty-five miles away.

It is, therefore, not unnatural that electricity should form an important factor in the motive power of Montreal.

As a matter of fact, for factory and machine shops drives, elevators, street railway power, pumping, etc., electricity from adjacent water powers is largely used at present in Montreal, and by proper management there is every reason to believe that its use in the near future will so increase that present local steam plants will be retained mainly as auxiliaries and reserves. Under normal conditions all public street lighting and practically all indoor lighting in this city is at present furnished by water powers.

BRIEF DESCRIPTION OF MONTREAL WATER AND POWER COMPANY'S SYSTEM AND GROWTH.

The water-works system making the greatest use of electric pumps in Canada, if not in America, is that owned and operated by the Montreal Water and Power Company. On this account, for the purposes of this paper, a brief description of the general system of that company and mention of its growth may not be out of place. It is proposed to limit, for the most part, the present

paper to a discussion of the problems involved in the large electric pumps used by the above company.

The city of Montreal proper is bounded on one side by the River St. Lawrence and on all of the three other sides by independent outlying municipalities. These extend from the river on the west side, around behind the mountain and the city to the river again on the east side. From river to river, by way of the shortest main supply pipe which could be laid for them all, is over 15 miles, and an altitude of over 600 feet above the river is reached on the way, in one of the principal municipalities.

These municipalities are now the towns of Cote St. Paul, Verdun, St. Henry, Ste. Cunegonde, Westmount, Cote des Neiges, Outremont, St. Louis de Mile End, St. Denis Ward (now a portion of the city formerly the town of Cote St. Louis), De Lorimier, and Maisonneuve (see Plate I).

In 1891 the Montreal Island Water and Electric Company, now incorporated as the Montreal Water and Power Company, obtained franchises for a long term of years to supply all these municipalities with water; with the exception of Verdun and De Lorimier, which have since come in, and Cote des Neiges, now negotiating with the company for its water supply. Two of these towns, Ste. Cunegonde and St. Henry, had at that time their own supply from the present source of the above company. The others either had no public supply or obtained their water through large meters from the city of Montreal.

The first step in organizing a general supply system was naturally to connect all these municipalities together in such a way that they would obtain their supply from the most available and feasible source. The source decided on was the St. Lawrence River above the city, thereby utilizing the 36-inch intake pipe of the old Ste. Cunegonde water works. The water is taken at a point 1 650 feet (approximately) from the shore and is pumped directly into the mains.

The work of connecting up the different municipalities was completed in 1898, and the present supply system established. From the nature of things three lifts were found necessary, one of 200 feet from the river forming the main supply. This supply is pumped through force mains approximately 6 500 feet long, and then distributed through the gridirons of the towns in front of

the mountain lying "below the hill" and at only a slight elevation above the average river level. The population receiving its supply from this lift is approximately one-half of the present total population supplied. In order to supply most of Westmount, and a large part of the territory behind the mountain, a second lift of 270 feet was established. The pumps at the 200-foot level take their water from a catch-basin of relatively small capacity, which receives the surplus water of the low-level system. These again pump directly into a reservoir of 8 000 000 Imperial gallons capacity (approximately) at an elevation of 470 feet, and also into the mains, there being no separate system of rising mains. This lift supplies practically all the other territory both in front of and around the mountain (see Plate I).

The pressure for the low territory like Maisonneuve, etc., is suitably controlled by regulators. This is, of course, not the most economic final plan, but at present the amount of water let down through the regulators is not over 25 per cent. of the whole supply. A plan to establish a low-level reservoir at a suitable elevation and connected with the back territory by a low-level gravity main around the western spur of the mountain is now under consideration. The execution of this plan will become important as the "back" territory grows.

Besides the two lifts mentioned, there is a third, established in 1898 for the supply of a few houses on top of the Westmount Mountain. This is a lift of 180 feet (approximately), and as yet of small importance in point of size. To-day over 80,000 people are being supplied in this way.

Seven and one-half million Imperial gallons are consumed daily, and the pumping at all three stations is done by electric pumps. The low-level station is at the river in St. Gabriel Ward of the city proper, and is called St. Gabriel Station. The intermediate station is on Clarke Avenue, Westmount, at an elevation of 200 feet, and is called the Clarke Avenue Station. The remaining station is at the reservoir and is called the Mountain System Station.

The pumps at the low-level station in 1898 were two in number — one an old-type crank and fly-wheel quadruple Holly of about 750 000 Imperial gallons capacity and the other a duplex direct Snow steam pump of about 3 000 000 Imperial gallons capacity, (see Fig. 1). At Clarke Avenue there were two direct duplex

— MONTREAL WATER & POWER CO —

PLAN OF

— ST GABRIEL STATION —

Scale 1" = 10'

— Montreal July 1900 —

— Prepared by

H. J. P. P.

Chief Engineer (H) W & P Co —

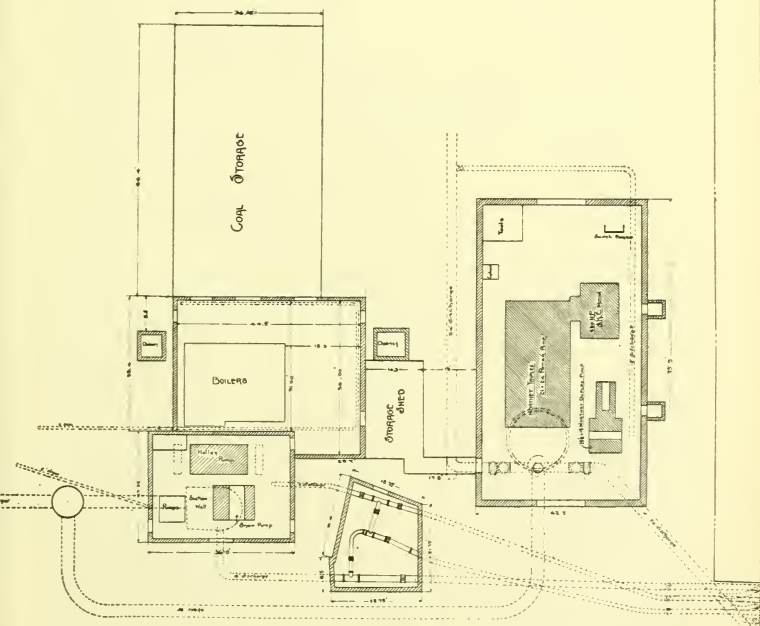


FIG. 1.

steam pumps; one of 2 000 000 and one of 1 000 000 Imperial gallons daily capacity. The larger pumps were added to each station as the consumption in the front grew and before the back territory was connected to this source.

The population had more than doubled in the four years preceding the completion of this work of connecting up all the towns. The distribution systems of the towns were extended during that period in even a greater proportion; so that, when finally the pipe system was ready to supply the whole territory, it was apparent that additional pumping capacity was necessary at the lower station if the company was to supply all the water from its own source. An additional capacity of 5 000 000 Imperial gallons was then decided on for the lower station.

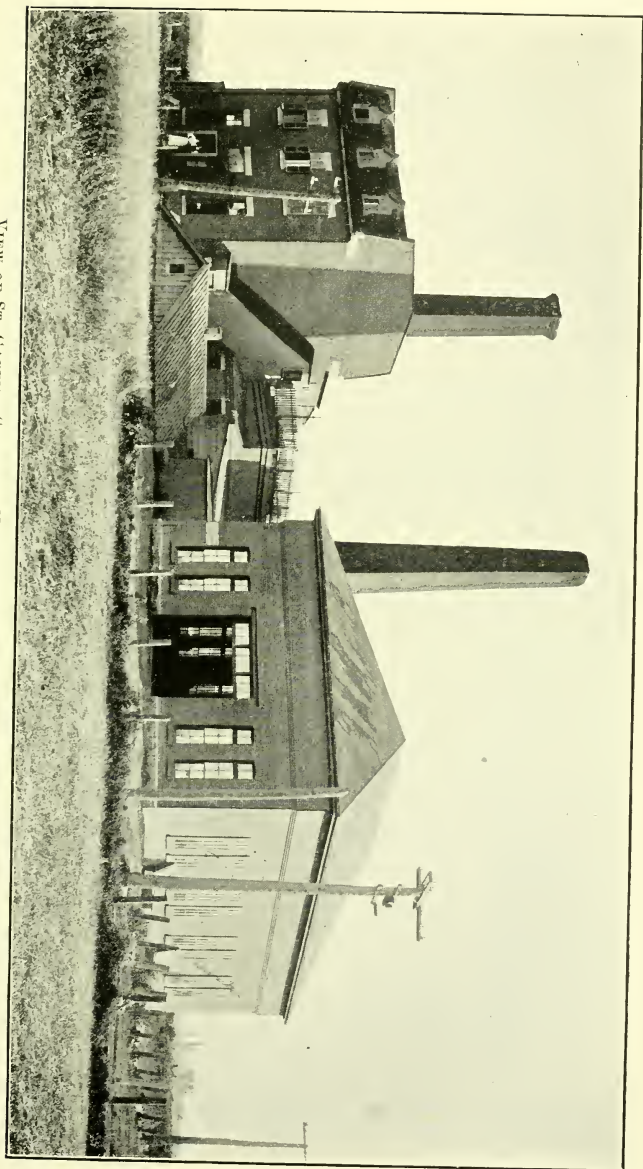
At that time the Chambly and Lachine Rapids water powers were in successful operation and offering power at attractive rates in the city. Moreover, the load curve of the electric companies had then a severe peak between 4 and 8 P.M., due to the incandescent lighting. This peak during the winter nearly reached the limit of their full capacity. During the other 20 hours there was more than three times as much unused power. Accordingly, by arranging to take the greater portion of power during the 20 hours outside of the peak load, very reasonable flat rates were obtained.

The capital cost of a 5 000 000 Imperial gallon electric pump was then considerably less than that of a steam plant of equal duty reckoned on a steam basis. The estimated attendance was only two-thirds of that for a steam plant. Electric pumping was therefore decided to be worth trying on this comparatively large scale.

Accordingly the 5 400 000 Imperial gallon triplex electric pump now running at the lower station was installed, and put into operation in 1899 (see Figs. 1, 2, and 3, and Plate II).

DESCRIPTION OF FIRST ELECTRIC PUMP INSTALLED AT THE LOWER STATION OF MONTREAL WATER AND POWER COMPANY.

This pump is a 21-inch by 24-inch horizontal double-acting outside center packed power pump, and is direct connected through single reduction gearing and a "Worrall" friction clutch to a 480-horsepower S. K. C. synchronous motor. The frequency of the



VIEW OF ST. GABRIEL STATION — NEW ELECTRIC STATION IN FOREGROUND AT RIGHT.

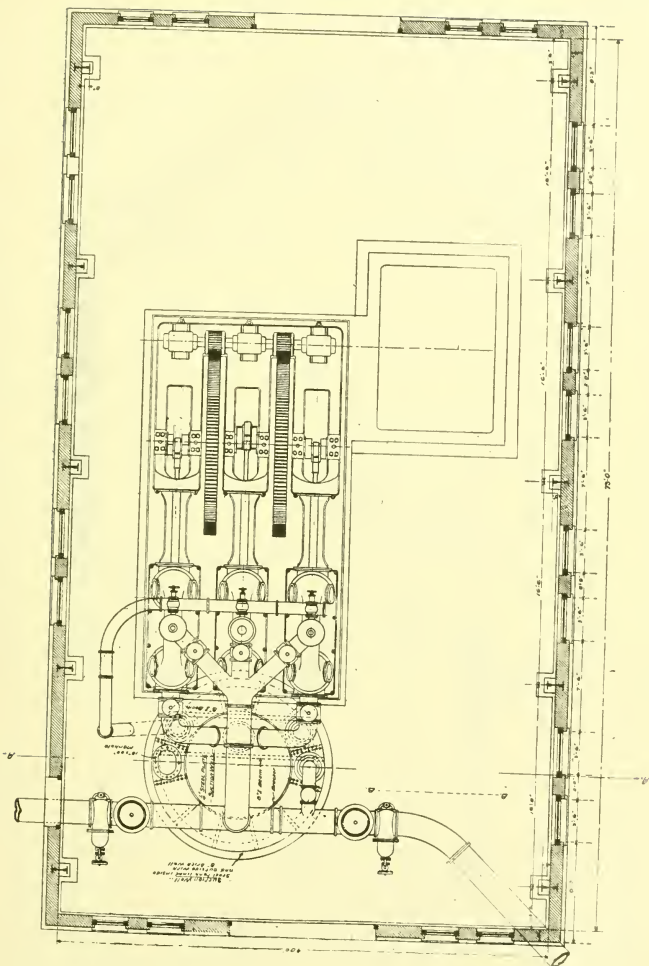


FIG. 2. PLAN OF ST. GABRIEL STATION.

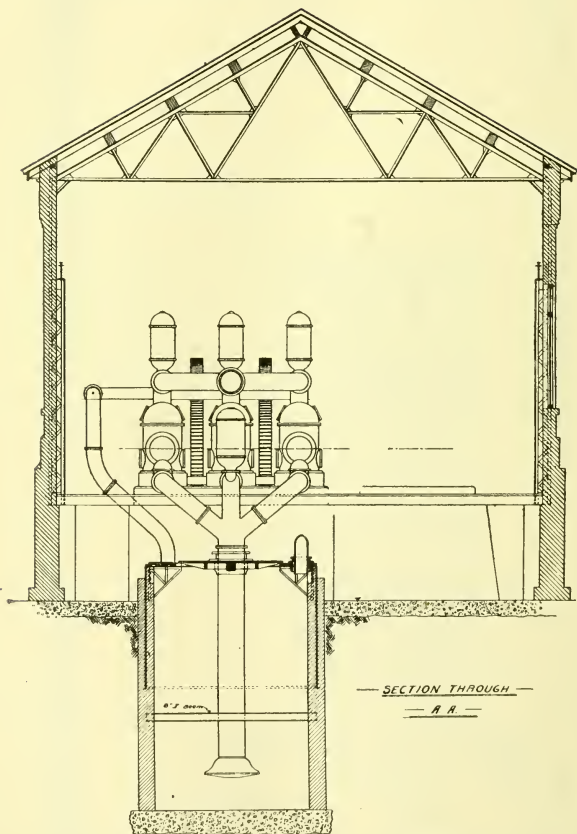


FIG. 3. SECTION OF ST. GABRIEL STATION.

power was 66 cycles per second and a 22-pole machine was adopted. This gives the comparatively low motor speed of 180 revolutions per minute. A piston speed of about 80 feet per minute was fixed, and single reduction gearing adopted with a ratio of 8.88. The gearing arrangement was made symmetrical by using two large gears on the crank shaft, one on each side of the middle pump. There are six main crank-shaft bearings, and consequently no overhanging cranks. The jack shaft carries two pinions engaging with the gears. This shaft is carried by pillow blocks resting on the frame of the power end.

The valve area is 65 per cent., there being 36 $3\frac{1}{2}$ -inch valves in each deck. The water chambers are of the externally smooth vertical, cylindrical type, having internal ribs.

The rigid frame carrying the jack shaft and crank shaft is tied to the pump ends in the usual way by heavy castings, which form the guides for the cross heads. This makes a very symmetrical and pleasing design, with at the same time almost a maximum compactness (see Plates III and IV).

Other principal data concerning the power end of this pump are as follows:

2 C. I. Gears	178"	pitch diam.	160	Teeth	3.494	Circular	pitch.
2 C. I. pinions	20.12"	"	18	"	"	"	"
Reduction ratio, 8.88.							

Average speed of pump shaft has been maintained at 21 revolutions per minute. The three-throw crank shaft is a steel forging, 10 inches in diameter through journals and crank pins, and 12 inches diameter at gear hubs; over all length 16 feet 2 inches. Steel pinion shaft is $7\frac{1}{2}$ inches diameter through bearings, $9\frac{1}{4}$ inches at pinions.

OTHER DATA.

Rectangular locomotive type connecting rods, 6 feet long center to center. Cast-steel cross heads, circular brass shoes, cross-head pins 7 inches diameter. The main bearings consisted originally of solid phosphor-bronze boxes and journals as well as the crank-pin journals. The bronze plunger rods are $4\frac{3}{4}$ inches diameter. The three pinion-shaft bearings were of the spherical self-aligning type common to electric generators and motors. They were babbited. The water end was provided with the usual

suction run around pipe, a discharge air chamber over each uptake, and one main suction air chamber. Discharge pipe is 20 inches diameter, suction 24 inches diameter. Separate suction and discharge stop gates are provided for each pump, so that any or all pumps could be cut out at will. In addition, a main hydraulic bypass valve was provided for starting and also for reducing the load on the motor during the four hours of the peak of the load of the electric power company. By means of this valve the pressure is held at any desired point below that of full load.

There was also provided an 8-inch spring relief valve of the Ashton type for each pump. These remained set at the same maximum pressure. There are, of course, the usual main discharge, check, and foot valves. A feature of this installation was a new steel intake well, or rather tank, below high-water level in the river, and a 36-inch steel intake pipe connection between this and the 36-inch wooden intake pipe to the old station.

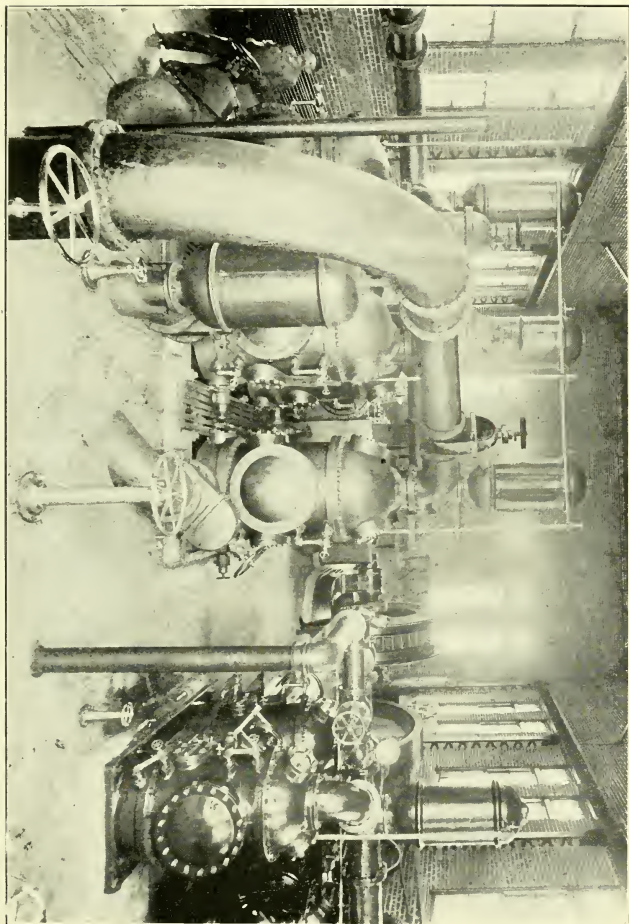
The air-charging device is the usual water column and air valve arrangement.

BRIEF DESCRIPTION OF THE MOTOR.

The motor, as above mentioned, is a 480-horsepower two-phase 66-cycle 2 400-volt synchronous machine of the S. K. C. type, that is, a stationary field and armature with a revolving inductor. There are then no evolving coils whatever, merely a cast-iron spider carrying laminated steel pole pieces. A feature of this machine is its large air gap as compared with induction motors. This gives perhaps greater security in its operation.

The fields of this machine are excited in the usual way by a belted 10 K.-W. D. C. generator. This little machine is shunt wound, and has a rheostat in both field and armature by which the exciting current of the motor is adjusted. The starting motor is a small 15-horsepower S. K. C. two-phase 500-volt induction machine, which can be thrown in or out of gear with the 5-foot 4-inch cast-iron spur gear carried on the motor shaft. The speed of the starting motor is regulated by a water rheostat in its motor, by means of which the large motor, when in mesh with the starter, is brought into synchronism with the line.

There are the usual ammeters, voltmeters, etc., on the switchboard, as well as fuses, lightning arresters, etc. No wattmeters



WATER END VIEW OF ELECTRIC PUMPS AT ST. GABRIEL STATION.

were provided on account of the power being bought on a flat rate based on the maximum load.

The lower voltage required for the starting motor necessitates two transformers, one in each phase.

During the four years this machine has been operating, the company has had every reason to be satisfied with the motor itself. One stator coil was burned out some years ago, due to the motor going out of step on a short circuit and not being taken off the line in time.

As long as normal conditions are maintained on the line this machine runs with little trouble. The type, and more especially this particular machine, has not sufficient regulation to stay in step when a sudden drop in line voltage of any considerable amount occurs.

Unfortunately, however, for this type much auxiliary apparatus is found to be necessary. A flat on the commutator of the exciter, not quite enough resistance in its fields, may cause, and has caused in this case, a shutdown of serious import. An extra armature is carried for the exciter; but this part of the apparatus has been uniformly found to be the weakest in the electrical equipment. Trouble has also been experienced with the starting motor transformers. Lightning, not grounded, burned them out at first. They were then provided with switches which enabled their primaries to be taken off the line when not in use. The above accident caused a shutdown of nearly a day.

The burning out of the little transformers for the synchronizing lamps has also shut the pump down.

On the whole, the points against a synchronous motor from the user's standpoint are found almost entirely in its auxiliary apparatus. On the other hand, these motors are virtually more efficient than their induction rival, inasmuch as the central station, or people selling the power, often take account, in fixing the rate, of the power factor of the motors they operate. By over excitation, as is well known, the power factor can be brought practically to unity; in other words, the wattless current is wiped out. In that case the consumer gets all the power he pays for; in the other only, say, from 70 to 90 per cent., depending on the ratio of the true to the apparent watts of the motor.

If no account of this is taken by the central station then every-

thing is in favor of the induction motor. However, more will be said about this type of machine when describing the Clarke Avenue plant.

To return to the operating of the pumps:

In order to reduce the noise of such heavy and comparatively high-speed gearing (980 feet per minute) to a minimum, raw-hide pinions were at first adopted. These were built up in the usual way with layers of raw-hide on a cast-iron center and held between shrouds in one piece with the centers. Steel bolts were inserted from end to end and an inch or more extra raw-hide face provided to allow for taking up shrinkage. These, when they ran well, were very noiseless and smooth, but it was soon apparent that they would not answer. The middle of the tooth seemed to spring away from the work and leave the ends near the shrouds to do most of it. This caused excessive wear. Moreover, the shrinkage with this raw-hide was so great that fiber had to be inserted at the ends in order to take up. Finally it became impossible to take up the shrinkage. The raw-hide seemed to loosen between the shrouds and the pinions failed by cracking at the root of the teeth.

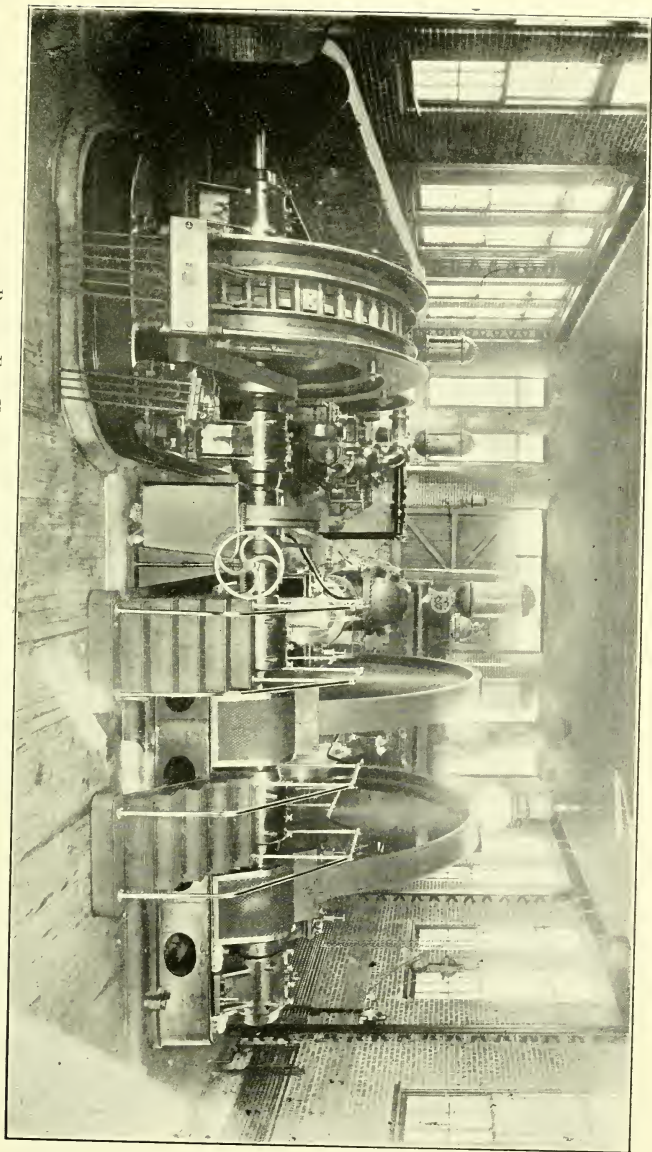
While this was going on the vibration in the large gears was extreme and the noise excessive.

It was essential to start this pump again without any unnecessary delay. Shrouded machine-moulded pinions were therefore put on and are running to-day, but, as might be expected, with considerable noise.

The wear has also been great, and the writer has concluded to abandon the two sets of gearing, substituting therefor one set in the pit next the motor. The frames are fortunately wide enough to allow a 21½-inch face, which will be ample for the 300 horsepower now transmitted by those gears. The crank shaft is also sufficient to allow this change. It has, moreover, been decided to get 10 per cent. more water out of that pump than at present by reducing the reduction ratio. A single pair, consisting of a machine-cut cast-iron gear and machine-cut steel pinion, is now on order for this pump.

Another source of trouble at the start was found in the phosphor-bronze boxes. There was too much anxiety for the water from this pump to give these a fair chance to come to a surface. They

POWER END VIEW OF ELECTRIC PUMPS AT ST. GABRIEL STATION.



took this occasion to heat badly and seize, and therefore had to be afterwards lined with babbit. Thus equipped, this pump has run without any extraordinary repairs since October, 1899, to the present time.

EFFICIENCY TEST.

By testing this plant with a Weston direct-reading wattmeter on the motor circuit, and indicating the water cylinders at the pump end with Crosby indicators, an overall efficiency as high as 85 per cent. from electric line to water has been observed. There is, however, considerable difficulty in observing the electric input with these sensitive wattmeters. This is due to the irregular oscillation of the needle. But there is every reason to believe that the above figure is within 2 or 3 per cent. of the truth.

Taking the average price of coal in Montreal, and the price per horse power of electric power, we obtain a duty from this pump on a basis of foot pounds per 100 pounds of coal, about 87 000 000.

The writer entered the company as chief engineer in September, 1899, while this pump was making its trial runs. When it was finally started it was at once apparent that the intermediate station on Clarke Avenue was not able to carry the additional load and thereby furnish all the water for the high levels and back territory. The boiler and chimney capacity were added to as a makeshift until something more permanent could be done, as it was at once made clear that the direct-acting duplex pumps at this station were neither sufficiently large nor efficient to do the work required. It was also clear, at the same time, that there was not sufficient force main capacity even for the present requirements between the lower pumping station and Clarke Avenue Station.

At the lower station, with the new pump running, the pressure was 145 pounds and the lift only 200 feet. The new electric pump was designed for 120 pounds pressure.

It was, therefore, decided to increase the capacity of the force mains and that of the pumping plant at Clarke Avenue. Accordingly, a new 24-inch main was laid to St. Henry, and 14-inch and 16-inch mains in that town — the former one across the town from east to west and the other straight north and south to Westmount. This gave three force mains, 12, 14, and 24 inches

in diameter, about 6 500 feet in length from the St. Gabriel Station to the St. Henry and Ste. Cunegonde gridirons. In passing, an interesting feature of laying force mains from this station to the main system is the necessary crossing of the Lachine Canal. The pipes have to be laid to give a clear 20-foot water way; and the bottom of the canal, where the company's crossings have been made, is a *quasi* quicksand. The work is, of course, done at the low water during the government repairs to the canal in the spring, but the material in the bottom renders coffer damming and trenching difficult.

This new work when completed reduced the pressure to 85 pounds, with 5 500 000 Imperial gallons consumption. It has now worked up to between 93 and 94 pounds.

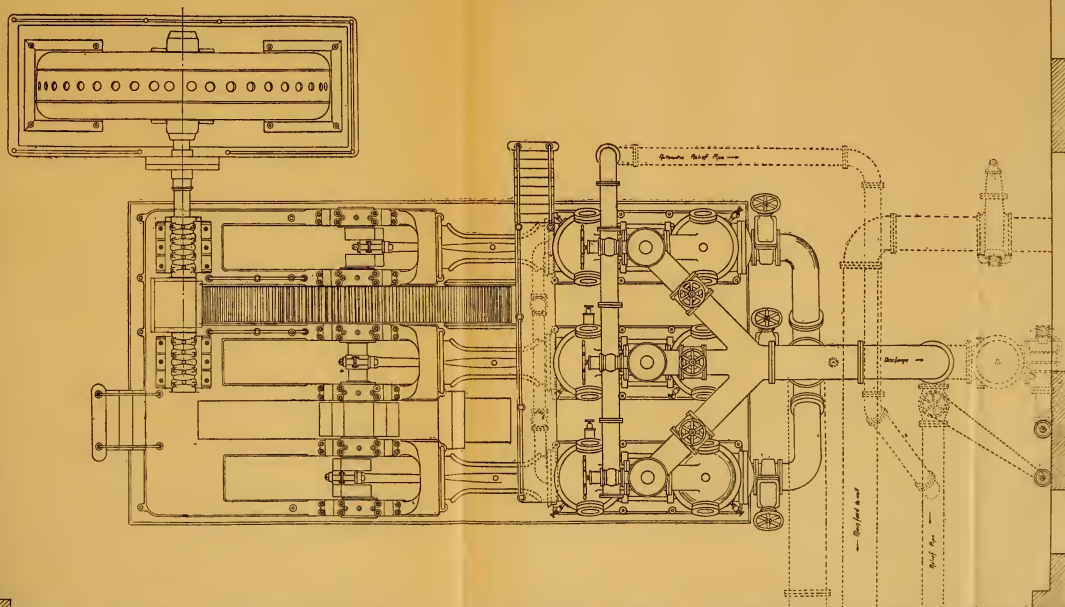
Besides the consideration of economy, there was another and perhaps a more important factor to consider in deciding on the type of pump for Clarke Avenue. The surrounding property is of a purely residential character and of a good order. The pumping station is on a very steep hillside. The smoke and hauling of coal up the hill incident to the operation of a commercial steam plant were much complained of by the neighbors, and proceedings were threatened. Knowing, however, that it was a choice between some noise and vibration in the immediate vicinity on the one hand, and smoke and dirt over a broader area on the other, the choice fell to an electric plant.

THE CLARKE AVENUE ELECTRIC PUMP,

(see plates v, VI, VII, VIII.)

The chief considerations here in connection with an electric plant were, after durability and efficiency, the avoidance of undue noise and vibration as above mentioned. Accordingly a pump was designed and installed in place in August, 1901, much like the first one in general type, but heavier and better built. Many mechanical changes were made, most of which were found to be improvements. Types of rotary pumps then on the market were considered but discarded.

The capacity of this pump was fixed to begin with at 4 500 000 Imperial gallons. This gives easily an additional 1 750 000 over the old steam plant at this station. The new pump is, however, designed to run up to 7 000 000 Imperial gallons by merely chang-



19 1/2 x 24 TRIPLEX POWER PUMP, CLARKE AVE STATION

MONTREAL WATER and POWER CO

* Montreal Aug 29, 1903

SCALE 1/2" = 1 FT.

Prepared by

H. H. Rector Chief Engineer

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ing the pinion. This is ample to provide for normal increase at this point for some years.

In event of a low-level reservoir being established at the proper level for the supply of the greater part of the territory, a heavier pump than the first one would be necessary. At the same time, such a large one would then not be required at Clarke Avenue. Accordingly, this pump was designed all around for a working pressure of 175 pounds, with a view to removing it to the river for the proposed new service. Its present head is about 118 pounds. This brought its weight (exclusive of motor) up to nearly 375 000 pounds, the lower pump being about 275 000 pounds. The chief differences between this pump and the other are, first, the gearing, which consisted of mortise gears and steel pinions; steel babbited boxes instead of phosphor bronze; marine crank ends; pillow blocks adjustable on frames; steel plunger rods instead of bronze and the carrying of these rods through the cylindrical plunger and securing by a taper in front and a locked nut at the back were other differences. There are also other minor differences.

This pump is a 19½-inch by 24-inch horizontal triplex, and the general arrangement of gearing was the same as the first. The motor being built for a slighter slower speed, viz., 160 revolutions per minute, allowed for the same piston speed with a correspondingly smaller reduction ratio. The gearing consisted of 2 mortise wheels carried by the same crank shaft, 140 maple teeth, 200.52-inches (16 feet 8½ inches) pitch diameter, 18-inch face, 4½-inch circular pitch (these teeth were hand dressed); and 2 machine-cut steel pinions carried by the same jack shaft, 25¾-inch pitch diameter, 18 teeth. Reduction ratio 7.88. The steel-forged three-throw crank shaft is 11¼ inches diameter through crank pins and journals and 13½ diameter at gear hubs; overall length 16 feet 11 inches. Distance between gears is 6 feet 3 inches.

Arrangement of bearings, etc., is as with the other pump. The jack shaft is connected with motor through a 500-horsepower 48-inch Worrall clutch. This clutch consists merely of a cast-iron disc keyed to one shaft which is gripped between shrouds keyed to the other. The usual lever and toggle joint link is employed to operate it. The disc and shrouds are beveled, which ensures accurate centering. On the whole, this clutch has been found most satisfactory. There was not the same necessity for a clutch

in this case as previously, on account of an induction motor being adopted, but a friction clutch of some suitable kind is considered almost indispensable with power pumps of this size.

The permanent induction motor for this pump, which was contracted for in 1901, was, at the time, the largest of the type ever built. There is only one other as large, and that is a duplicate built for the electric pump of the city of Montreal now being erected.

This machine, being a very special one of extraordinarily slow speed, was naturally late in coming. A temporary drive was therefore arranged so that the pump could be started in the summer of 1901 (see Figs. 4 and 5). This consisted of a 200-horse-power three-phase 600 revolutions per minute alternator, belt-gearred to a 10-foot pulley on a temporary jack shaft, erected on timbers from the permanent motor foundation. The regular clutch was used at this time and proved a very necessary part of the equipment.

This arrangement had a pinion-shaft speed of 100 revolutions per minute, which brought the load within the capacity of this temporary motor. This drive ran from August 1, 1901, to April, 1902, or eight months.

When this pump was first started it seemed satisfactory. The gearing made only a slight rumble and there was very little vibration. It seemed as if the ideal in electric power pumps had been reached. Soon, however, it was noticed that the wooden cogs were fraying, and the action of the gears consequently became less smooth. It was soon — in less than six weeks — necessary to re-cog these gears. This was done by taking one out and running the pump in the meantime with the other pair. After the first one came back, and while the other was away to be re-cogged, it was noticed that the gears ran better and lasted longer with one pair than with two. On investigating it was found that at the periphery of these 17-foot wheels there was a spring between them of over $\frac{1}{4}$ inch, when a tangential force equal to 150 horsepower at 100 revolutions per minute of the jack shaft was applied. This was, of course, due to spring in the crank shaft. When the stresses on the gears are considered in relation to the resultant of the three-crank effort curves, it is at once apparent that there is, during every revolution, a fluctuating load between these gears. This is brought about by the outside cranks, whose load is, from the

— MONTREAL WATER and POWER CO. —

SIDE ELEVATION - 191 x 21 TRIPLEX PUMP

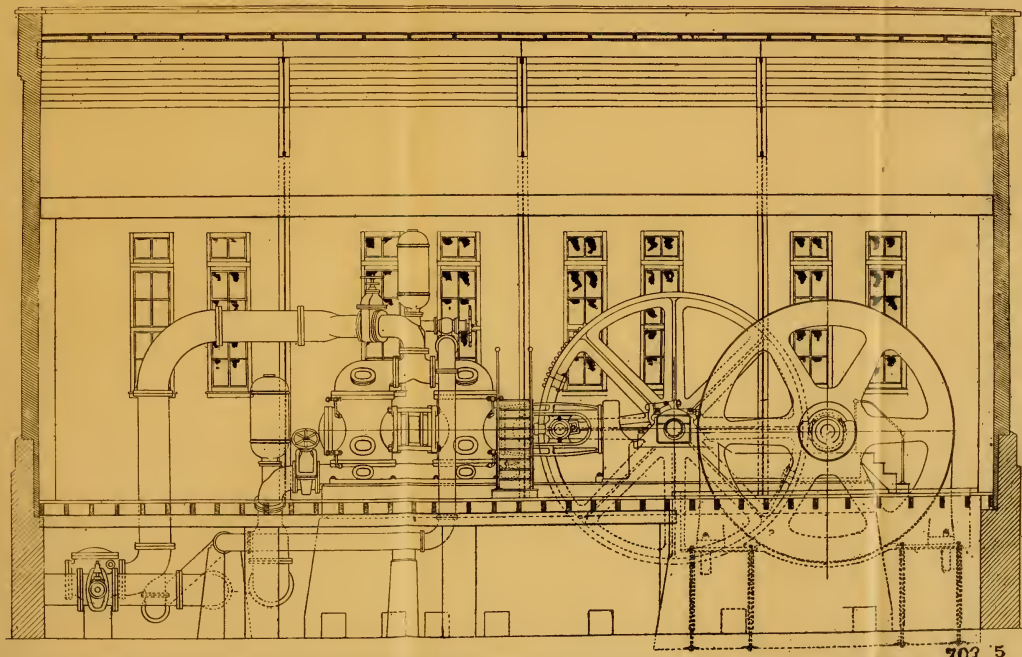
CLARKE AVE. STATION

Montreal Sept 5, 1903

SCALE 1/2"

Prepared by

H. N. Kline
Chief Engineer



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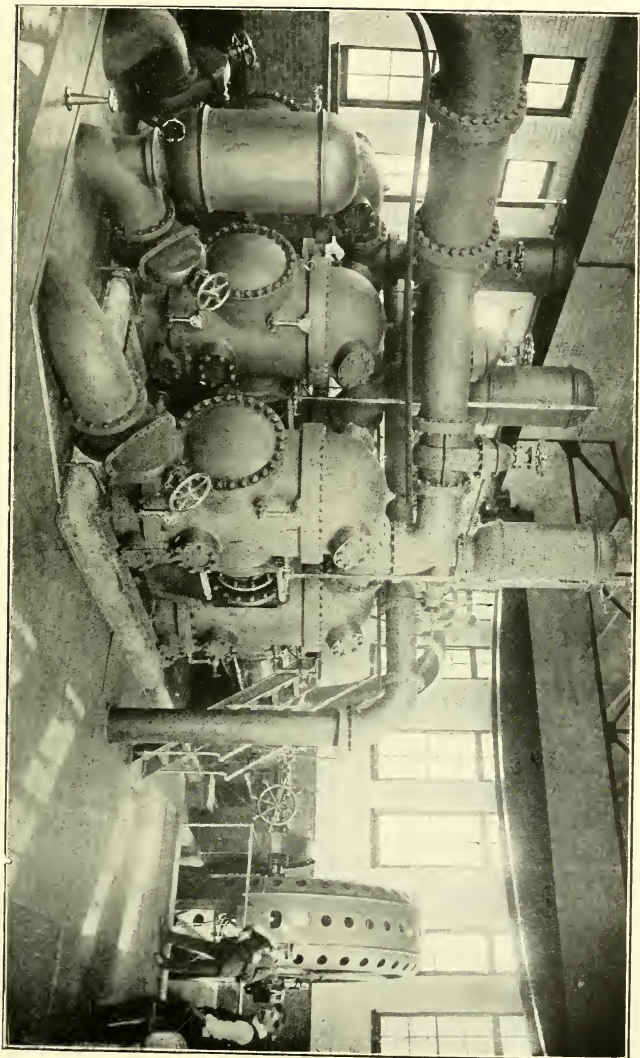
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GENERAL WATER END VIEW OF CLARKE AVENUE ELECTRIC PUMP.

It having been observed that the gears ran better when the working pair was in the pit next the motor, it was thought that a jack shaft of larger diameter would tend to smoothen operation. Furthermore, with a two bearing support for the pinion shaft as would obtain, it was decided to abandon the spherical bearings and substitute stiff bearings of a greater length. Accordingly a 10-inch pinion shaft with bearings of 3.9 diameters (approximately) was installed.

The particulars of this pair of gears are as follows: One machine-cut spur cast-iron gear 24-inch face, 179 involute teeth, $3\frac{1}{2}$ -inch circular pitch, pitch diameter 199.42 inches, or 16.61 feet.

The all raw-hide pinion has a 26-inch face, 24 teeth, 26.7-inch pitch diameter (approximately). Reduction ratio 7.45.

This pinion ran for six weeks, and then failed much as the others at the lower station did, but from another cause. The shrinkage was much less, the raw-hide undoubtedly being a superior article, but something happened inside the pinion which prevented it being taken up. It is the writer's opinion that the raw-hide contracted radially and got between the ends of the cast-iron centers carried by the shrouds. However, in spite of plenty of clearance at the ends of the pinion, it was found impossible to compress the hide in the middle so that it was sufficiently tight. The consequence was the load all came on the ends and the teeth got out of shape, causing extreme heating in the pinion. The coefficient of expansion of this substance being high, the ten $1\frac{7}{8}$ -inch steel bolts holding the raw-hide laterally were broken as quickly as they could be renewed. The raw-hide itself stood the test, and did not break as with the other. The raw-hide was not keyed to the cast-iron center or otherwise secured, except by the bolts passing through from end to end. While this pinion ran it was extremely noiseless at times, but atmospheric changes, particularly the amount of moisture in the air, seemed to have considerable effect on it. An appreciable variation in the running of the gearing was observable, apparently from no other cause than atmospheric changes.

A cast-iron pinion was cut as soon as possible and installed in place of the raw-hide one, pending the arrival of the pinion now running.

The first raw-hide pinion was, of course, the largest ever at-

tempted in face and mass of raw-hide. But in the writer's opinion the very quality to which raw-hide owes its noiselessness—viz., the spring—renders an all raw-hide tooth of such a length impossible for heavy work. The teeth, as above mentioned, spring away from the work in the middle, or point of maximum bending moment, and, the cast-iron teeth of the gear being relatively rigid, too much work comes on the ends, which in consequence show excessive wear in a few days. Unfortunately the writer was unable to hold a *postmortem* on this pinion, without which the above is offered as an explanation of its failure.

The pinion now running is one-third brass; that is, it is cut from a blank having a section of brass in the middle 8 inches wide, with 8 inches of raw-hide on each side. The whole is keyed as well as bolted to the cast-iron centers, which makes a rigid point in the middle of the face of the teeth. This pinion has run since April 9 last, and shows only a slight amount of wear. It is not, however, in point of noise much ahead of the cast-iron pinion. In fact, with its present slight wear it is doubtful whether it runs as smoothly as the iron pinion. The raw-hide people are anxious to try again, using an all raw-hide face having the raw-hide keyed to the centers. I understand they now have one of that type under way.

This pump runs only 20 hours a day, and there is therefore ample opportunity to take up the slack in the raw-hide, etc.

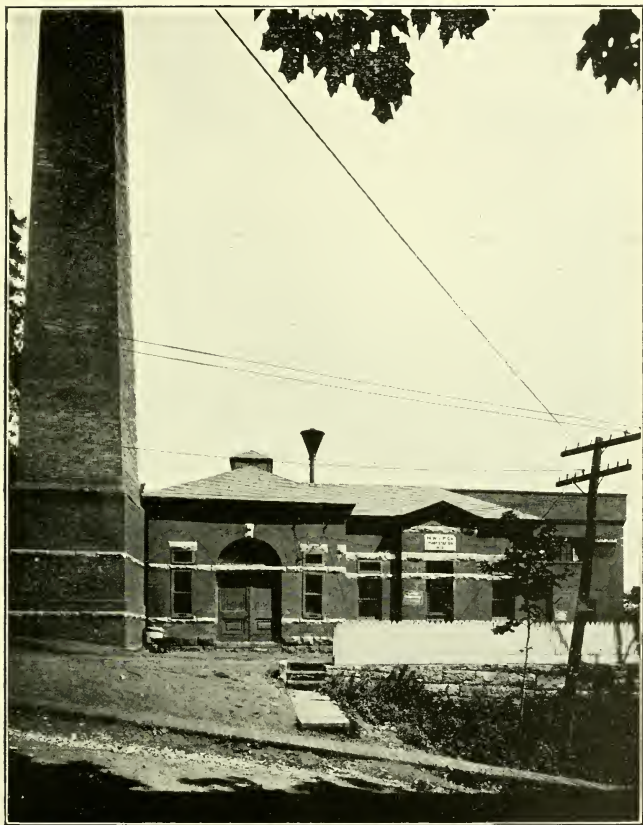
To those visiting this station during the convention it will at once be apparent why every effort should be made to minimize the noise of the pump.

Otherwise than the gearing, this machine has been most satisfactory from the start.

Both the lower station and upper are provided with 10-ton traveling cranes.

DESCRIPTION OF THE CLARKE AVENUE MOTOR.

The motor is a 400-horsepower three-phase 60-cycle 2 200-volt 90-ampères induction machine, having 44 poles and therefore a synchronous speed at 60 cycles of approximately 160 revolutions per minute. In order to keep up the power factor with that number of poles a very large machine with a very small air gap or clearance naturally results. The rotor is 13 feet diam-



CLARKE AVENUE STATION — ELECTRIC STATION IN REAR ON RIGHT.

eter and the stator 6 feet outside diameter. The clearance between rotor and stator is less than 1-16 inch.

The guaranteed power factor at full load is $91\frac{1}{2}$ per cent., full load efficiency 92 per cent., heating limit after 12 hours run 40° C. temperature rise at full load. An overload of 25 per cent. for 2 hours should not show a temperature rise of more than 50° C. at same efficiency. The above is a very liberal rating on this machine, as another 10 degrees would not be out of the way for regular running and 550 horsepower could easily be realized at that limit. The machine passed its test satisfactorily.

It must not be understood that this, with the later city duplicate, are the largest induction motors ever built in point of power. They are, however, it is thought, as large as any in that respect when rated on the same basis. But they are much larger in their diametrical dimensions than anything previously attempted.

This motor is started by first an auto starter in the stator. This is simply a series of transformers so arranged that the line voltage may be applied to the stator windings in gradual steps. This arrangement prevents the sudden rush of current so objectionable to the line and so frequently found in starting smaller induction motors. In the meantime the rotor is an open circuit, which after the full line volts have been applied to the stator is closed gradually through the resistance of a water rheostat. The starting current of this motor is only 30 ampères.

It would, of course, have been preferable from an operating point of view to have had this machine two-phase like that below, but, in order to meet the condition of the electric company supplying the power, three-phase had to be adopted.

This machine is considered a very satisfactory one, remembering that it was the first; the city motor has some slight mechanical improvements.

There has been no trouble like that experienced below in the operation of this motor. A strong short circuit on the line for a few moments makes no trouble in the pumping station.

The starting device is much simpler and less liable to get out of order. Even if it did, the motor could still be started by applying the full line voltage at one step. This would, however, not be agreeable in all probability to the central station people.

EFFICIENCY.

With good steam coal at its present price delivered at that station, the duty of this pump corresponds to 162 000 000 foot-pounds per 100 pounds of coal approximately.

The difference in duty on this basis between the two installations is due, of course, to the higher price of power below and slightly lower cost of coal — the latter on account of the difference in hauling and the former because some 24-hour power is used there.

This motor, as will be seen from the illustration, is absolutely self-contained.

The stator is in two parts divided along a diameter. The rotor is in one piece. The diameter of the shaft through the bearings is 10 inches. The bearings are not self-aligning, which, for a direct-connected machine like this, is considered an advantage.

The approximate weights of the parts are as follows: Stator — Top half, 23 500 pounds; bottom half, 29 500 pounds; rotor, 25 000 pounds.

As will be observed, the peripheral speed of this machine is fairly high, being over 6 500 feet per minute. This, however, in spite of the minute clearance and large diameter of the rotor, causes no anxiety with modern methods of rotor construction.

This equipment would have been most satisfactory from an operating standpoint if it had been thought possible to consider all metal gearing at the outset. Double reduction gearing was ruled out, both on account of its inefficiency, cumbersomeness, and liability to additional disturbance.

THIRD ELECTRIC PUMP.

The third electric pump was installed at the lower station, due to the following considerations:

The additional force and supply mains above mentioned between the lower station and Clarke Avenue reduced the load by more than 30 per cent. on the lower motor. The power contract entitled the company to more than it was possible to use under the new conditions in the same proportion. On this account additional pumping capacity at this station was contemplated in the scheme which included additional force main capacity.

As far as can be seen this is a satisfactory arrangement. The piston speed of this pump is 96 feet per minute at 32 revolutions per minute..

An additional 5 000 000 Imperial gallon electric pump is now under consideration for this station to meet the growing demand, and at the same time a 12 000 000 Imperial gallon reserve steam plant to be used only in emergency.

THE MOUNTAIN SYSTEM PUMP.

The electric pump used at the Mountain System Station is a small 8 by 10 inch single-acting vertical triplex, driven through double-reduction gearing by a $7\frac{1}{2}$ -horsepower 500-volt S. K. C. induction motor. The capacity of this little pump is approximately 100 Imperial gallons per minute.

As mentioned above, this supplies the people living on the Westmount Mountain. There are no special features about this equipment. An exact duplicate can be seen in dozens of cotton mills, etc., throughout the country. They differ from each other only in size and type of drive. No trouble has been experienced with this apparatus.

NEW ELECTRIC PUMP FOR THE CITY OF MONTREAL.

Before closing, mention should be made of an important similar installation now being erected for the city of Montreal at its high-level station.

The pump is, briefly, an 18-inch by 24-inch double-acting horizontal triplex inside plunger packed pump. This is to deliver 5 000 000 Imperial gallons in 24 hours and will be run at a piston speed of about 115 feet per minute.

The general gearing arrangement is similar to that finally adopted at Clarke Avenue, except that a hand-dressed mortise wheel and steel pinion will be used.

Pitch diameter gear 188.44 inches, 148 maple teeth, 4-inch pitch, 20-inch face. Pinion, steel, 31.83 inches pitch diameter, 25 teeth. Ratio 5.9.

As mentioned above, the motor is electrically identical with the Clarke Avenue machine. A change in the method of adjusting the rotor in its housings has been adopted, so that in case of wear at the journals the motor can be easily raised by the wedges

and screws provided for the purpose. The housings or cheeks have been flared outwards and the sole plates widened to give greater stiffness.

TO SUM UP.

The chief problem encountered with large reciprocating electric pumps is in suitably reducing the speed of a comparatively high-velocity prime mover. It is undesirable at present on account of the cost to build an induction motor to run at less than say 150 revolutions per minute with a frequency as high as 60 cycles.

The more modern power installations like that at Shawinigan Falls generate at 30 cycles. This would be very desirable power for reciprocating electric pumps. Unfortunately such a low frequency cannot be obtained in Montreal. The Shawinigan power used in the city is transformed at a local sub-station to 60 cycles so as to coincide with the original Lachine system.

The high-speed turbine pumps, so much used abroad and now being introduced into the United States, may prove, everything considered, more desirable as electrically driven pumps than the reciprocating type.

The principal advantages of large electric pumps in this district are a high comparative duty, which, when the power is on a flat rate, remains absolutely constant. This is a great advantage and eliminates the personal equation of firemen and attendants. They certainly require less attendance than steam pumps of an equal capacity beyond the small sizes. They are clean and generally cause less annoyance to surrounding property holders. They run with less oil and waste. In this district, with the larger sizes, the capital cost of the equipment per horse power is less than a steam plant of equal duty.

A great disadvantage is that not unfrequently the water supply is at the mercy of an outside electric system, which is liable to accident, often causing frequent interruption. In other words, the operation of the pumps is not, from the nature of things, entirely under the control of the water works.

MUNICIPAL USE AND WASTE OF WATER.

DISCUSSION.*

MR. HARVEY D. EATON. I should like to ask Mr. Hill what would be a fair amount for a pupil to consume per day, if he can give an estimate of that, under proper regulations.

MR. WILLIAM L. HILL. I should think four gallons would be plenty.

MR. EATON. What is the usual amount required for a single flushing of a closet?

MR. HILL. That depends on the style of closets. It varies from 3 to 7 gallons. It takes nearly a gallon per day per pupil to flush the closets they have now. The smallest consumption appearing on this table is 2.3 gallons per pupil in a school with 218 pupils. In one school with 868 pupils the consumption was 3 gallons *per capita*.

MR. EATON. Do you think those school buildings are fairly furnished with conveniences so the children are properly accommodated?

MR. HILL. I think they are.

MR. LEONARD METCALF. Is there any apparent reason for the high consumption in any of the schools showing the very high consumption per pupil? That is, are the numbers of pupils very small in those cases?

MR. HILL. Here is one school with 68 pupils, where the consumption is 497 gallons, and here is another school with 426 pupils, where the consumption is 117.

MR. FRANK L. FULLER. I should like to ask Mr. Hill if, after the meters were introduced and the large consumption reported, any large leaks were discovered in the cases where the high figures appeared.

* This discussion (of paper by John Venner, Chief Inspector, Bureau of Water, Syracuse, N. Y., read at the Montreal Convention by Mr. Wm. R. Hill) was not available for publication with the paper on account of the illness of the reporter. The paper may be found in the September, 1903, issue, p. 268, vol. 17.

MR. HILL. There is no question that there was a good deal of leakage. The meters had only been on three months when this table was made up, and no doubt Mr. Venner later on can give you some very valuable information with regard to leaks in school buildings as well as in other buildings. Here is one school which started with 188 gallons for the month of March, and in the month of May it had got down to 104. Here is one which starts with 44 gallons, and that got down to 28. I read the figures for the last month and not for the first month. The figures for the first month would have been even larger than those I read.

MR. FULLER. Were the meters read every day?

MR. HILL. No, they were not; they were read once a month.

MR. KENNETH ALLEN. What style of water closet was used — whether the individual closet or closets which are flushed in series?

MR. HILL. I do not know; I could not answer that. I had nothing to do with the preparation of this paper. Mr. Venner, the chief inspector, prepared the paper and requested that I should read it. I notice here that in a school of 574 pupils the *per capita* consumption was 6 gallons, in another school with 471 pupils it was 4 gallons, and in another with 353 pupils it was 3.9 gallons; so I think 4 gallons is quite sufficient.

A MEMBER. Do you know whether the buildings are heated with hot air or by steam?

MR. HILL. I do not.

A MEMBER. When you speak of self-closing faucets have you any particular type or make in mind?

MR. HILL. I have not; no.

THE MEMBER. We have had trouble, and would like advice in selecting.

MR. HILL. There are some four or five very good styles, but just what they are is not now fresh in my mind. They are also using a great deal of water in Syracuse for motor purposes for operating fans for ventilating the schools, and that is not included in this table of consumption at all.

MR. FULLER. That is unmetered water?

MR. HILL. Yes, that for the motors is unmetered, but Mr. Venner is placing meters on them, so he will be able later to give you the information in regard to that. Three and three-fifths

per cent. of our entire consumption going to 34 schools certainly shows an enormous wastage of water.

MR. F. L. FULLER. It seems to me that this paper which Mr. Hill has read gives us another example of the foolish way in which water is sold, not perhaps so much now as formerly, but it seems absurd that a commodity that has any value at all should be sold or distributed in the way that water is, in many towns. My own town, Wellesley, perhaps furnishes a good illustration of this point. For a number of years after the works were built, our water was sold by the faucet, and the consumption increased very rapidly, doubling in a year or two. When our consumption reached about 93 000 000 gallons a year, if I remember correctly, we began to put in meters, and although the number of takers continued to increase, the consumption began to decrease, and continued to decrease somewhat in proportion as the use of meters increased, and for a number of years, perhaps six or eight, our consumption has been less than the maximum it had reached before meters were introduced. We now use, I should say, 80 000 000 gallons a year, whereas ten or twelve years ago we were using 93 000 000 gallons, and probably we have twice as many consumers now as then.

I read the meter in my own house every morning, or try to, just for the sake of seeing how the consumption varies, and it is quite interesting to keep that record. We have five in the family generally, and the consumption is perhaps 5 or 6 cubic feet for the minimum, while on washing days it will run up to from 10 to 15 cubic feet, which is a good deal less than many of the figures which Mr. Hill has read. Of course the use of water in a private dwelling house, the legitimate use of it, is a great deal larger than it would be in a school building; that is, the water used for washing clothes and for washing dishes and such uses as that would not pertain to a school building. The amount of water used in the water closets might be practically the same, but I should suppose that would be less *per capita* in a school building than in a private house. But this all points, certainly, to the reasonableness of the use of meters. When a meter can be bought for from \$8 to \$10 which will register all the water which an ordinary house will use, and which will last 12 or 15 years, — I don't know just what the life of a meter is, — it seems as though it were a wise invest-

ment for a town or a city to make. In Wellesley the town owns the meters and the people have no expense on account of them, except to keep them from freezing.

MR. EATON. I should like to ask Mr. Hill if such a condition of wastage of water as he has shown to exist in Syracuse does not indicate a pretty serious impairment of the efficiency of the fire service; in other words, if it does not reduce the pressure.

MR. HILL. That would be true where there was a system of small-sized pipes, like some systems I know of, for example, at Waterville, Me., where they have 31 miles of pipe and 12 of it is less than 4 inches in diameter. I think a large consumption or waste of water there would seriously interfere with the fire service. In fact, on these 12 miles of main they have no fire protection whatever, in my opinion. In a city where they have large mains the wastage in school buildings would have a very small effect, but the general wastage might have a very serious effect.

MR. EATON. I meant if such conditions prevailed in all the services, not only in the schools.

MR. HILL. Oh, yes, I should think so; yes, indeed.

MR. F. W. DEAN. In regard to the matter of fire protection with small pipes, I was somewhat instrumental in having the Metropolitan water introduced into the town of Lexington, where I live. They had a well system there, and the water was pumped by a small pump into a standpipe, and there was considerable head. There was a good deal of feeling in the town against introducing the Metropolitan system, because it was thought by many persons that the Metropolitan Water Board was anxious to get all the towns possible in, in order to help pay the bills for the establishment and maintenance of the system, though of course anything that Lexington could have contributed in that direction would have been but a drop in the bucket. It is rather amusing that one of the strenuous opponents to the Metropolitan system had his house located about three thousand feet from the main line, and a 4-inch pipe led in that direction. His house caught fire, the first house which caught fire after this agitation occurred, and it was entirely consumed, for there was not force enough to throw the water upon the roof.

HISTORY AND DESCRIPTION OF THE MONTREAL
WATER WORKS.

DISCUSSION.*

MR. J. C. HAMMOND, JR. I would like to ask Mr. Janin if they have an overflow to their high-level reservoir, or if they have to watch the gages.

MR. JANIN. Of course we have an overflow, but the gages are watched. We pump only in the daytime. We have a reservoir capacity of about 1 750 000 Imperial gallons, and the consumption is about 2 200 000. The present pump is worked twelve or fourteen hours a day. The reservoir is left full every night, and the next morning the water level is found to be down six or eight feet when the pumping is resumed at six o'clock. The pumping is maintained all day, and along towards four or five in the afternoon we find we get near the overflow, and then the pump is run more slowly until six or seven o'clock, at which time the reservoir is left full.

MR. FRED BROOKS. Will you please explain what is meant by "frasil"?

MR. T. W. LESAGE.† Frasil is the name given in this country to ice which forms in swift running water in cold weather.

MR. FRANK L. FULLER. What we call anchor ice?

MR. LESAGE. No; there is considerable difference in the formation of the two kinds of ice. It is not what is called anchor ice, which generally forms in calm water. Frasil or slush ice is formed in very rapidly running water. The water in our rapids is running at the rate of six miles an hour or more, and this frasil ice forms in very cold weather on the surface of this swift running water, and then slowly sinks, or partly sinks, and attaches itself like

* This discussion (of paper by George Janin, C.E., Superintendent, Montreal Water Works) was not available for publication with the paper on account of the illness of the reporter. For the paper, see page 272, vol. 17, September, 1903.

† Assistant Superintendent Montreal Water Works.

anchor ice to the bottom, or to any other ice that happens to be there, and it impedes very much the flow of our aqueduct, as it lodges in a spongy, slushy mass under the surface ice.

In the fall of the year, before our settling basin in the head race freezes over, late in November or early in December, if there are two or three days when the temperature is less than ten above zero, it generally happens that the gratings at the entrance of the wheel pits are completely clogged by this frasil ice. It makes a nearly watertight joint, so that there is hardly a drop of water goes into the wheel pits through the gratings. That state of things continues for a night or so, or until the surface of the basin is covered with ice, and then we are free from the trouble to our wheels for the remainder of the winter. During most of the winter time, however, the frasil will flow with the current into the entrance of our aqueduct from the Lachine Rapids, and it thus interferes with the flow of the water.

It has certain distinguishing features from anchor ice, although just at the moment I cannot explain them. We have had considerable discussion on the subject, and there are certain theories about the formation of this ice, but of course I have only spoken of the practical side or of the troubles it occasions. The name of it here is frasil, or slush ice; the old river men have always called it frasil.

MR. LEONARD METCALF. I would like to ask whether you have had any trouble with electrolysis on your pipe system, from the trolley lines.

MR. LESAGE. We have had a little trouble with electrolysis, but not to any great extent. We have had it only in the near neighborhood of our street railway power house, on one or two streets. Our trolley system is pretty well safeguarded, I believe with return conductor wires, and probably that is one reason why we have not had more interference on that score.

MR. METCALF. Is the trouble on the service pipes or on the mains?

MR. LESAGE. We have it especially on the mains. The power house is situated about 300 yards from the canal, and they take water therefrom for condensing purposes through two 24-inch mains which run very close to one of our 6-inch water pipes, and we have had more trouble with that pipe than with any other.

The pipes running into the power house seem to act as storage batteries, I suppose, and we get the full benefit of it on this 6-inch pipe. Aside from that we haven't had much difficulty. Our service pipes are very little affected, except those in close proximity to the power house.

MR. KENNETH ALLEN. What hydrants do you use here?

MR. LESAGE. They are an adaptation of the Matthews style of hydrant; we make them ourselves, and they have a rather heavy outside casing for frost protection purposes.

MR. HAMMOND. At what depths are your mains?

MR. LESAGE. Generally they are six feet; the smaller pipes, less than 8-inch diameter, have six feet on top.

MR. F. W. DEAN. I presume it states somewhere in the paper what the source of the electric power is to be for the new high-service pump, but I don't remember it, and therefore I will ask the question as being the easiest way to find out.

MR. LESAGE. No; it is not stated in the paper. The contract was made originally with the Lachine Rapids Hydraulic and Land Co., but since that time all the electric light and power companies in Montreal have been merged into one, and all are under one management at the present time. We have a five-years' contract with them to supply the power.

MR. DEAN. What horsepower will be required?

MR. LESAGE. From 385 to 400.

MR. DEAN. I suppose that is with an alternating current?

MR. LESAGE. Yes.

MR. DEAN. What voltage is to be used?

MR. LESAGE. Twenty-two hundred volts. I believe you are going to have a paper on this subject later on by Mr. Pitcher, which I think will give all this information.

A MEMBER. What do you have to pay?

MR. LESAGE. Owing to competition at the time we got advantageous rates. As our plant is to run at present we expect to get along with twelve hours' pumping, and we figured that if we ran at night we could get a much cheaper rate than for day running. The prices offered were for twelve hours' pumping for the required amount of horsepower, 385 to 400, at a flat rate of \$26 per horsepower per year for day running, or \$20 for night running, and we took the night running rate, that is, from 10

P. M. to 10 A. M. It is a question, however, whether we will be allowed to run this machinery at night. The pumping station is in a strictly residential portion of the city, and it may be that the residents will not like the night running, especially in the summer time.

MR. METCALF. Can you tell us what you have to pay here for coal?

MR. LESAGE. Up to last year, or the recent rise, a year or a year and a half ago, we used to get coal for \$3.25 to \$3.50, but now I believe we are paying somewhat over \$4 for Cape Breton or Nova Scotia coal, which comes by water. Of course imported by rail in the winter time it is more expensive.

MR. METCALF. You mean for a long ton, of course?

MR. LESAGE. No, a short ton, 2 000 pounds.

MR. ALLEN. Do you know how your coal compares with the Pennsylvania coal?

MR. LESAGE. There are three or four varieties of coal which we get, and I could not say about any particular kind. Some of it is better than others. There have been comparisons made between our coal and the Southern coal, but I don't know that there have been any recent comparisons, and I cannot state anything definite with regard to the coal that we get at present.

MR. FULLER. I suppose that your works are more than self-supporting?

MR. LESAGE. That opens up a pretty large question in Montreal. Our water rates are at present the subject of considerable discussion. We have what we call the water rate here, a general municipal tax, which is not meant to be the price of water, but is generally applied for street cleaning and lighting, fire protection, police tax, and everything else. This water rate is based on percentage of the rental. It is $7\frac{1}{2}$ per cent. of the assessed rental. Take a property on a good residential street, for example; it may be assessed for rental of \$800 or \$1 000 yearly, and there will be perhaps only three or four people in the house, and the rate will be $7\frac{1}{2}$ per cent. on that amount, or \$60 or \$70 yearly water rate; while down in the poorer portion of the city, where the house will only be assessed at say \$120 a year, and there will be perhaps eight or ten persons in it, and the women of the house may take in washing and otherwise use perhaps ten times as

much water as is used in the uptown house. You see can the difference in the water rates that they pay. It weighs heavily on the rich man and lets the poor man off. The city, however, has been accused of making too large a profit on its water, which is more or less true, but of course the management of the water department does not get the amount of money which is collected.

MR. FULLER. Do you use any meters at all?

MR. LESAGE. The number of meters is somewhat limited, about 1 100 of all sizes. We use them just for large industrial establishments, factories and such like, so as to prevent waste.

MR. HAMMOND. What do you use for house service pipe?

MR. LESAGE. Lead pipe altogether, except in 2-inch we use galvanized iron.

MR. P. KIERAN. What is the quality of the water, bacterially and chemically?

MR. LESAGE. It varies a good deal. I don't know that we have had any very recent analyses made, but our water compares very favorably with most waters. In the spring of the year when the river is running pretty full the water is cloudy and turbid. Although we take our supply from the St. Lawrence River, the water we get is mostly Ottawa River water. As you are aware, Montreal is on an island, and at the upper extremity is the confluence of the two rivers, the Ottawa and the St. Lawrence; the Ottawa River strikes the shore of the island, and thus we generally get Ottawa River water at the intake of our aqueduct. It is a little less hard than the St. Lawrence River water, and a little more highly colored with vegetable matter. There are certain times in the winter when a short stretch of water at the head of the island becomes obstructed by ice, and probably for a month or six weeks all the Ottawa River water comes down at the back of the island, and we get then St. Lawrence River water at the intake of our aqueduct.

COVERING THE NATICK, MASS., RESERVOIR WITH A CONCRETE ROOF.

BY FRANK L. FULLER, CIVIL ENGINEER, BOSTON, MASS.

[Read September 10, 1903.]

The water supply for the town of Natick was introduced in 1874, the late M. M. Tidd being engineer. The source was Dug Pond, a tributary of Lake Cochituate, situated about one mile southwesterly from the business center of the town. The water was pumped into an open reservoir on Broad's Hill in the easterly part of the town.

The reservoir does not appear to have been originally well built, for in 1876 the bank on the west side gave way, and it was entirely emptied. The break was repaired by the town at an expense of \$645.90.

In regard to the paving on the inside slopes, the superintendent says in his report for 1878: "The slopes inside are a continual source of trouble, and will be till they are either paved with granite blocks, with granite chips underneath to prevent wash and growth of weeds and grass, or that the small stones which are there should be laid in cement grout to make them water-tight, thus preventing the water from becoming roily at every high wind." In his report for the year 1883 the superintendent says: "There is one source of trouble which should be remedied, that is, the growth of weeds on the bottom, — which is very filthy, — which has become rooted so that it grows very heavily and quickly when the water is warm, and causes it to taste. This can be overcome by cementing the bottom, which would save the expense in a few years, as it takes about three days to clean it, with a number of men, which could be done in as many hours if the above suggestion were carried out."

Nothing was done in this connection until 1902, during which year the work described in this paper was completed.

In 1886 the sum of \$71.66 was expended in cleaning the reservoir.

At the annual meeting in 1890 the town authorized the water commissioners to "repair and enlarge the reservoir." This was done by day labor under direction of the superintendent, the contract for paving stone, broken stone, and cement being awarded to the lowest bidder. The old slope paving was removed to within about 5 feet of the bottom, and used in building a core wall through the reservoir embankment. The new paving consisted of granite blocks 1 foot wide, about 7 inches in depth, and averaging about 18 inches in length, laid on 5 inches of broken stone placed upon the old bank. The paving blocks were laid in cement mortar of good quality, as indicated by the difficulty in removing the stone at the points where piers of the outer row were to be built. Only on the southerly side, at about the elevation of high water, where the effect of waves and ice was the greatest, were any open or poor joints found. No settlements, except some very slight ones along the line mentioned, were discovered. The work is a credit to the late Mr. J. W. Morse, at that time superintendent of the Natick Water Works and for some years a member of this Association, and to the workmen under him. (See Plate I, Fig. 1.)

At this time the embankment was raised 2 feet, and high water level $3\frac{1}{2}$ feet, in order to furnish a better supply at the residence of Mr. H. S. Hunnewell, situated near the Wellesley line.

As originally built, the reservoir was 17 feet deep, high water being considered as 14 feet above the bottom, or 3 feet below the top of the embankment. After the height of the embankment was increased the reservoir was 19 feet deep, and high water was fixed at $17\frac{1}{2}$ feet above the bottom, or $1\frac{1}{2}$ feet below the top of the embankment.

The original paving was of small stones, except at the bottom, where those forming the footing course were of good size. The portion within five feet of the bottom, which was allowed to remain, was pointed with Rosendale cement, and presents a fairly smooth and even appearance. The core wall was built by excavating a trench near the center of the embankment and filling it with the stone which formed a portion of the original slope paving, laid in mortar probably composed of Rosendale cement and sand. The wall probably extends somewhat below the original surface of the ground. On a plan made by Mr. Tidd, dated February,

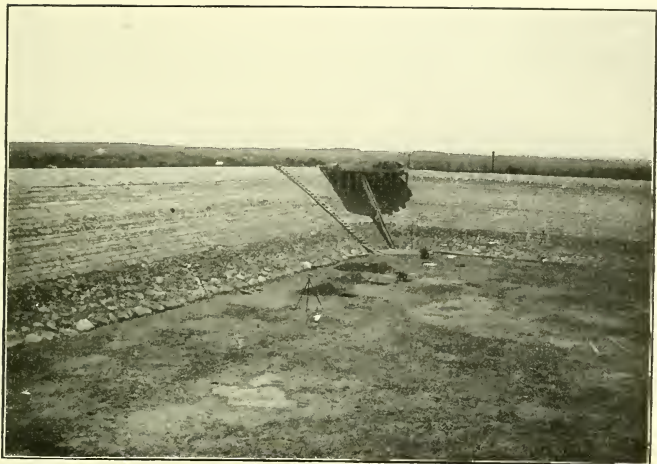


FIG. 1. — RESERVOIR BEFORE CONSTRUCTION OF ROOF WAS BEGUN.

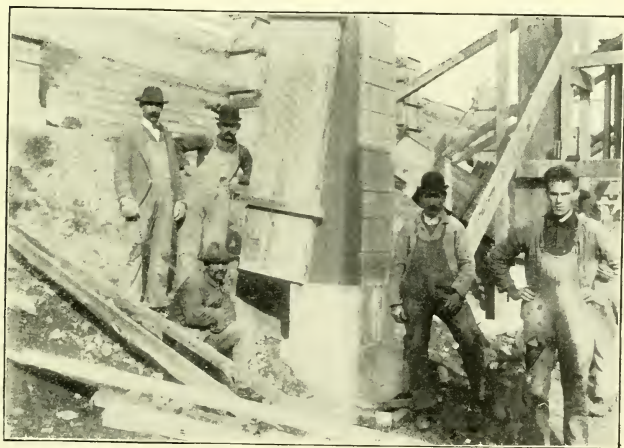


FIG. 2. — REMOVING FORMS FOR PIERS.

1890, a section at a point, probably on the westerly side, and near the southwest corner of the reservoir, shows the wall as 1.5 feet thick at the top and 2.5 at the bottom and 8.0 feet high. Its top is shown as 1.5 feet below the new top of the reservoir bank, and it extends 1.5 feet below the old surface at that point.

Whether the wall was built according to this plan, the writer has no means of knowing. At the point where a cut was made through the embankment for the entrance of the new 18-inch force main, the bottom of the core wall is about 3.5 feet above the bottom of the reservoir, and about 4.8 feet thick. The new force main is 15.17 feet north of the old 12-inch main, and the thickness and depth of the core wall at the point mentioned may be due to its proximity to the old force main.

Until the laying of the new force main the reservoir had no overflow or waste pipe, and on one occasion the water, due to excessive pumping, overflowed the bank. No especial damage was done, however. The engineer had only his pressure gage to rely on, which is not sufficient, especially where there is not an overflow pipe of good capacity.

The new granite paving extended entirely to the top of the embankment, and the inside edge of the reservoir at the top is practically rectangular, with rounded corners of about 38.5 feet radius. (See Fig. 1.)

The average inside dimensions of the reservoir at the top are 217.0 feet from east to west, and 212.0 feet from north to south. The corresponding figures for the bottom are 159.8 and 154.3 feet.

The area within the top of the slope paving, which is the area of the top of the concrete roof, is 44 730 square feet, and the area at the bottom is 24 570 square feet.

The capacity of the reservoir before covering, with high water 17.22 feet above the bottom, was 4 340 000 gallons. With the same high water, it is now 4 280 000 gallons

A NEW WATER SUPPLY.

For several years the water supplied from Dug Pond had been of poor quality and insufficient in quantity. The water often had a disagreeable taste or odor, especially in hot weather and sometimes in winter.

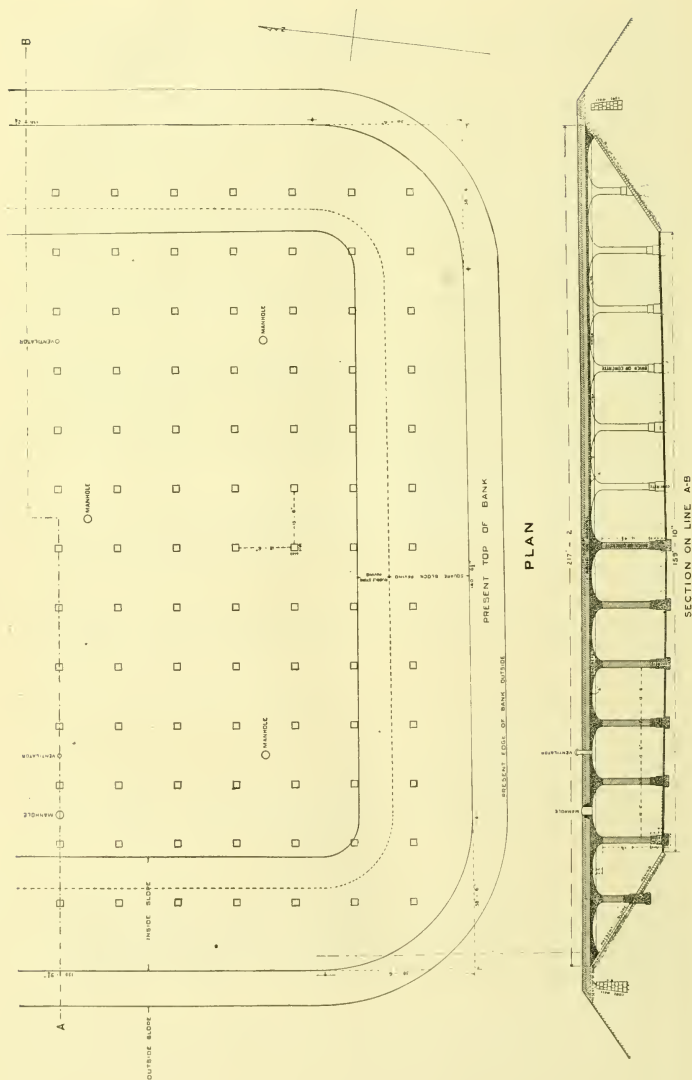


FIG. 1.—PLAN AND SECTION OF CONCRETE ROOF OF NATICK RESERVOIR.

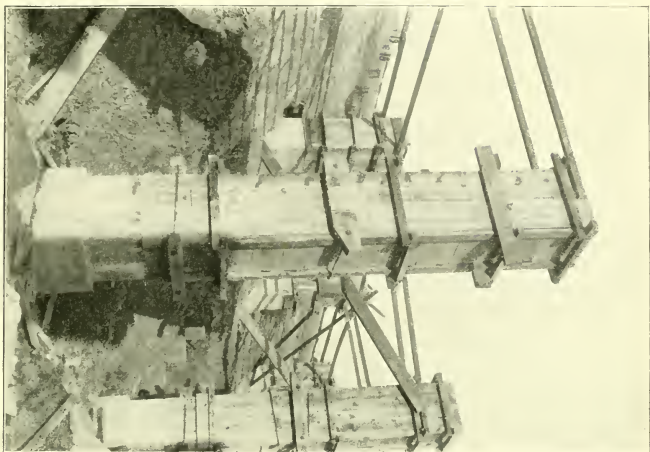


FIG. 1.—FORMS FOR UPPER SECTION OF PIERS.

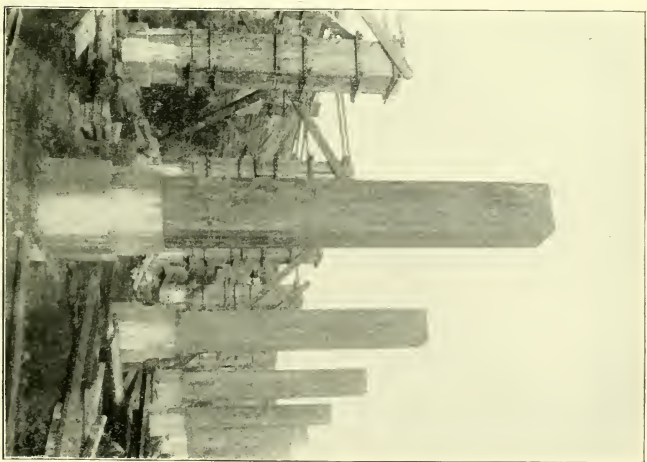


FIG. 2.—PIERS.

The pumping station was situated upon an arm of the pond, into which a brook * which drains a part of the thickly settled portion of the town empties. The water of this brook was badly polluted, especially before the construction of the sewerage system in 1896.

The town had for some time been advised by the State Board of Health to secure a new supply, and, in the spring of 1902, appropriated \$150 000 to be expended in obtaining such a supply, building a new pumping station, installing a new high-duty pumping engine, laying a new 18-inch cast-iron force main from the new pumping station to the reservoir, and covering a part or the whole of the existing distributing reservoir.

Tests made by Mr. Percy M. Blake, C.E., in 1899 or 1900, established the fact that a supply of ground water, probably amply sufficient for the needs of the town, could be obtained upon land owned by the town, situated on the borders of Lake Cochituate on the southerly side of Worcester Street.

The adoption of this supply, and the now almost universally recognized necessity of storing ground water in covered reservoirs, made the addition of a roof, or covering, to the existing open reservoir almost imperative. Late in the spring of 1902 surveys were made, plans and specifications prepared, and proposals asked for the various items of work to be done, except the pipe laying, which was done by the day by townspeople under direction of Mr. George W. Travis, Superintendent of the Natick Water Works and member of this Association.

CONSIDERATION OF METHODS TO BE ADOPTED.

Considerable time was spent in studying the open reservoir and its condition and the best way of securing the desired result. It was at first thought that it might be sufficient and less expensive to cover only one-half of the reservoir, but this would require the construction of a heavy cross wall, sufficient to resist the pressure of a depth of about eighteen feet of water on one side only. The expense of this wall would pay a large part of the cost of covering the other half of the reservoir.

The question also arose whether the slope paving should not

* This brook was originally a branch of Pegan Brook, but had been diverted into Dug Pond before the city of Boston acquired Lake Cochituate and Dug Pond in 1847.

be removed, a portion of the inner slope excavated, and a heavy masonry wall built on the four sides, from which the covering arches should spring.

Approximate computations and a careful consideration of the subject led to the adoption of the method of covering about to be described.

On careful examination the slope paving was found to be of such excellent quality, and the banks so hard and compact, that it was considered safe to allow the concrete arches to abut directly upon the slope paving. This would save a large expense in removing the slope paving and excavating part of the bank and building expensive retaining walls, which seemed unnecessary.

The covering of the entire reservoir would give the town the advantage of a 4 000 000 instead of a 2 000 000-gallon reservoir. Moreover, the appearance of the reservoir entirely covered would be much better than it would with one-half covered and one-half open, even if the second half were filled with water.

It was, therefore, decided to cover the entire reservoir, and the completed work fully justifies the course taken.

DESIGN OF PIERS AND ROOF.

From the beginning it was assumed that a large number of piers would be required. Whether a system of lintel arches between piers and parallel segmental circular covering arches, or groined elliptical arches, should be used, was considered. The less cost of concrete, as compared with brickwork, and the possibility of its erection by unskilled labor, made its use desirable wherever possible. Groined elliptical arched vaulting can easily be constructed of concrete, and is economical in material. In the case of lintel arches and segmental circular covering arches, the lintel arches and the filling over them would be almost of necessity of brick. The centering for the groined arch vaulting is probably more expensive than that required for the circular covering arches. Taking all things into consideration, however, the groined elliptical arch method of covering was adopted. The specifications were so drawn that brick or concrete piers could be used.

The price bid by Mr. F. A. Snow, whose proposal was the lowest, was \$9.50 per cubic yard for concrete and \$14.00 for brick



FIG. 1. — REMOVING FORMS FOR PIERS.

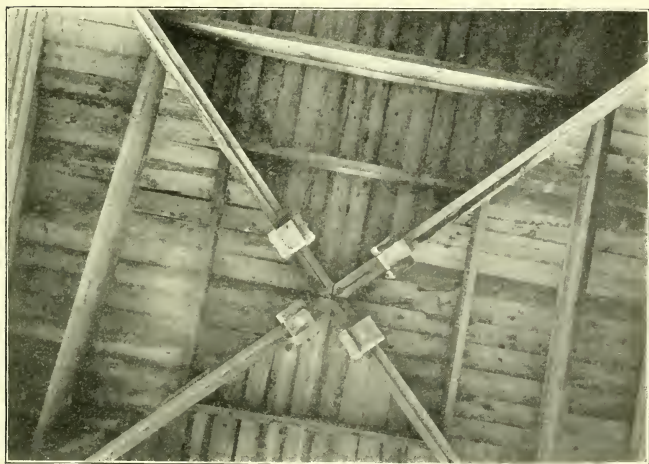


FIG. 2. — UNDER SIDE OF ROOF CENTERING, SHOWING CLAMPS CONNECTING FOUR QUARTER SECTIONS.

piers. Concrete was, therefore, adopted, the saving to the town thereby being \$1 828 80.

Thirteen rows of piers, with 13 in a row, or 169 in all, spaced 15 feet 2 inches on centers, were adopted for supporting the roof. The reservoir, as before mentioned, was not exactly rectangular, but the piers were arranged so that the four lines bounding the outside of the system of piers formed an exact square, 183 feet 8 inches on each side.

In this rectangular system of piers the number of rows was such as to make it necessary that only the outside rows of piers should be built into the inner slopes of the reservoir. (See Fig. 1.)

Ribs of different lengths were required in the centering between the outer rows of piers and the slope paving, according to the slightly varying dimensions of the reservoir. (See Plate IV, Figs. 1 and 2.)

The piers and their foundations, located within the foot of the slope, have the following dimensions: Pier foundations are 3 feet by 3 feet by 1 foot 6 inches deep, the top of the foundation being at the level of the under side of the 4 inches of concrete covering the bottom. The first section above the foundation is 2 feet 4 inches by 2 feet 4 inches, with a height varying from 1 foot 6 inches to 2 feet 6 inches. The tops of these sections are all at the same elevation, which is 1 foot 6 inches above the bottom of the reservoir at the outer edge. As the reservoir bottom has a uniform slope from the outer edge to the center, where the bottom is 1 foot lower, it will be seen that the length of this section varies according to its location.

The second section above the foundation is 2 feet by 2 feet by 1 foot 6 inches.

The third, or upper section, is 1 foot 8 inches by 1 foot 8 inches by 12 feet 5½ inches.

In the four outer rows of piers the foundations were carried below the original surface of the ground, and were generally of larger horizontal and vertical dimensions. The length of the other sections varied according to circumstances.

The elliptical arches used in the design of the roof have a span of 13 feet 6 inches and a rise of 2 feet 9 inches. The thickness of the concrete roof at the crown is 6 inches and over the piers 3 feet 3 inches.

The top of the concrete roof is level with the average top of the slope paving at its upper inside edge, and extends to it.

CONSTRUCTION.

Concrete alone was used in foundations, piers, and roof. The specifications provided that the concrete used should be of either the Alpha, Atlas, Iron Clad, Lehigh, Vulcanite, or Brooks-Shoobridge brand.

Of these the following amounts were used: Atlas, 2 200 barrels; Brooks-Shoobridge, 200 barrels; also 200 barrels of Alsen's American Portland, making 2 600 barrels in all.

The concrete was to be composed of 1 part of cement, by measure, $2\frac{1}{2}$ parts of sand, and $4\frac{1}{2}$ parts of broken stone or screened gravel. The sand and stone were to be of acceptable quality. Mr. Snow decided to use screened gravel. This and the sand, which were from the same pit, were of excellent quality, the sand being coarse, clean, and sharp. The concrete was mixed by hand and quite wet. As carried in a wheelbarrow there was usually a thin layer of water over it. But little difficulty was had in filling all voids, and on removing the centers but little porous or defective work was found, due, it is believed, in a considerable degree, to the wet condition of the concrete, which could be easily rammed into place.

Work was begun at the southeast corner and progressed from east to west, the northwest corner being the finishing point. The mixing platform, until the piers were finished, was at the top of the bank at the southwest corner.

Excavations of the proper size were made in the bottom for the pier foundations and grade marked for the top of the concrete. The wet concrete, with the aid of a little tamping or cutting with a shovel, entirely filled the hole, and, what is of considerable importance, the top, when set, was perfectly level and smooth, ready for the forms for the next section.

For foundations of this character, good concrete has much to recommend it.

The forms, or bottomless boxes, as they might be called, for the 2 foot 4 inch by 2 foot 4 inch sections, were placed upon the concrete foundations and set in line one way, by a transit instrument. The box was placed as nearly in position as possible on the other line by the eye. Two stakes were then driven into the ground on

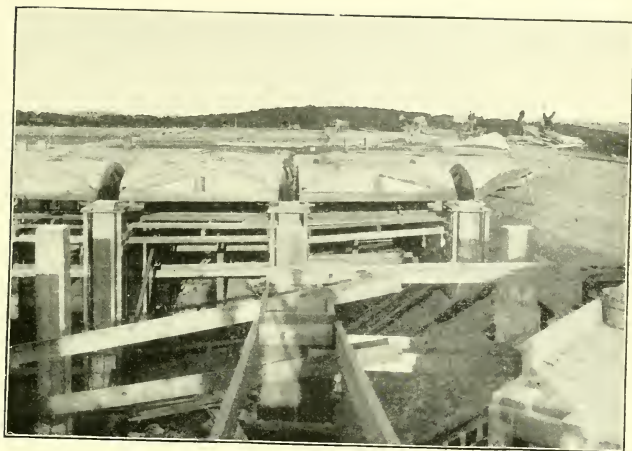


FIG. 1. — CENTERING AND BRACING.



FIG. 2. — CENTERING AND CONCRETE AT SLOPE PAVING.

each side of the box, so that pieces of 2-inch by 1-inch furring would rest on the top of the stakes and against the sides of the boxes. The furring being nailed to the tops of the stakes acted as guides, between which the boxes could slide a short distance either way. The middle box was then centered by setting the instrument over the center line of the reservoir, at right angles to the line first given. Then by means of a steel tape attached to the middle box at a point on the center line of the reservoir, marked upon the side of the box, the remaining boxes were pushed or driven in the proper direction, between the guides, till each was at the correct distance from the center. Two additional pieces of furring, one on either side of the box, were then laid upon the guides and at right angles to them and pressed close to the box. They were then nailed to the guides, securing the box or form in position.

Grade for the top of the section, which was the same elevation at all the piers, was then marked on the inside of the boxes, and they were ready for filling with concrete.

The two center lines, or axes of the reservoir, had been carefully established, both on the bottom and on the top of the reservoir bank. From these the center line of each row of piers had been accurately fixed by stakes in the bank at the top. By setting an instrument over a stake and sighting to the corresponding one on the opposite side of the reservoir, line for that particular row of piers could be easily given with certainty that it was correct. Great care, of course, was necessary with the tape measurements that the piers might be properly spaced upon the line given by the transit instrument.

The forms for the 2 foot by 2 foot by 1 foot 6 inch sections were set in the same manner, generally before the forms for the section below had been removed, as the upper form could be secured in place by cleats nailed to the lower. In a day or two, or when needed, the lower form could be removed, leaving the upper one to be removed at the proper time.

The forms for the upper, or 1 foot 8 inch by 1 foot 8 inch by 12 foot 5½ inch section of the piers, were raised into place upon the top of the 2 foot by 2 foot section, by resting one end upon the top of the completed section and the other on a cement barrel placed opposite the pier. By means of a rope attached to the

upper end, two or three men upon a run or platform at the level of the top of the finished pier, with the help of a few men below, could easily pull it into a vertical position.

The bottom of the form was then easily adjusted, by the eye, upon the top of the 2 foot by 2 foot section, as the outside of the upper form was of the same dimensions as the top of the concrete section upon which it was to rest. The bottom of the form was then secured in place, generally by means of 2 inch by 3 inch pieces, nailed or spiked on either side, from form to form, extending from the east to the west slope of the reservoir.

The bracing at right angles to the line of piers being built was generally by two pieces of 2 inch by 3 inch spruce, spiked to the form directly south, or if that form had been removed, by bracing from the lower pier sections on either side.

The tops were then put in line one way by the instrument and spaced by tape measurement nearly in the same way as in the case of the 2 foot 4 inch by 2 foot 4 inch sections already described.

The tops were secured in place one way by 2 inch by 3 inch pieces spiked to the form to the south, or, if that had been taken down, by a long 2-inch plank on either side, abutting against the lower section of the pier to the north and that to the south. The bracing in an east and west direction was the same as at the bottom.

A timber platform or run at the level of the top of the piers, supported on sill pieces resting on the bottom, furnished the means of reaching the top of the form from the mixing platform with wheelbarrows.

The concrete was dumped from the top into the long forms. By putting the 20-inch pieces into the front of the form at the bottom only as fast as it was filled, as explained under "Centering," an opportunity was had to ram the concrete and also to keep stones away from the sides of the forms by means of a spade. This precaution prevents the stone from showing on the surface of the pier and gives it a smoother and more finished appearance.

The run, or longitudinal platform, extending in an easterly and westerly direction, could be moved northerly with bars by men stationed along the length of it, in the same way that a railroad track is often moved laterally. After one row of piers had been built by means of it, it was moved northerly one space, or about fifteen feet, and an additional row built.

The minimum time allowed before the forms for piers were removed was about four days. Generally they were allowed to stand longer.

The concrete for the roof was usually put on in sections 30 feet 4 inches wide, the joint being along the crown of the arch. A 6 inch by 6 inch spruce timber was laid along this line, and the concrete left flush with its upper surface.

The minimum time allowed for the removal of roof centers, after the concrete had been put on, was ten days. In some instances the centers remained in place two weeks or longer, or until they were needed for another portion of roof, or in other cases until it was desirable to remove the supports for the purpose of concretizing the bottom.

A small amount of excavation was necessary on the bottom, and the material removed was thrown, by successive lifts, to the roof and spread over the concrete, protecting it from too rapid drying. In addition to this an amount sufficient to make in all a thickness of about one foot was taken from a borrow pit on the north side of the reservoir.

It was intended to cover the concrete roof to a depth of two feet, but before this could be done the borrow pit became so frozen that only about one foot, as before mentioned, could be obtained, and the remainder was not put on till the following spring.

A few fine cracks appeared on the upper surface of the concrete, generally over the piers. It was thought that they were produced by a slight yielding of the centers at some point between the piers. When it is remembered that the concrete supported by each pier weighs 15 tons, and that before it is set its weight is entirely on the centering, it is not surprising that a very slight settlement, sufficient to form cracks around the unyielding pier, should take place. In no case were they thicker at the surface than a penknife blade, and appeared thinner below. Sometimes liquid grout was poured over them, which filled them, and they were not noticed again. In no case did they increase appreciably in size after discovery.

Very cold weather occurred suddenly on December 9, 1902. The concrete roof was entirely built, except a portion about 15 by 25 feet on the west side over the new 18-inch inlet and outlet pipe.

The thermometer dropped to 10 degrees below zero outside the reservoir. Some frost formed on the inside of the roof, adjoining the opening, and the bottom was slightly frozen. The opening was covered with a large piece of canvas and boards, and it is not known that any damage was done.

All centers not needed to close the opening, and all waste material, were removed through this opening and the last centers put in place.

January 3, 1903, the weather being suitable, the last concrete on the roof was put in place and covered to protect it from freezing. On January 13 the centers were removed and the roof was completed.

In the meantime, four inches of concrete was being placed on the bottom, including a finishing coat of American Portland cement and sand. The temperature in the reservoir was just above freezing, as shown by the following figures:

<i>Date.</i>	<i>Temperature.</i>	<i>Date.</i>	<i>Temperature.</i>
Dec. 11, 1902	30°	Dec. 29, 1902	34°
„ 22, „	36°	„ 30, „	35°
„ 24, „	36°	Jan. 1, 1903	34°
„ 25, „	36°	„ 2, „	35°
„ 25, „	35°	„ 12, „	34°
„ 27, „	34°		

On January 16, 1903, the sides and bottom were thoroughly washed by means of a stream from a fire hose attached to a connection in the bottom of the reservoir, water being furnished by direct pumping. The dirty water flowed off at the center of the reservoir through the new 8-inch waste pipe.

FORMS AND CENTERS.

The forms for the lower sections of the piers were of 2-inch spruce plank, planed on the inside, the grain being horizontal. They were spiked together permanently at two corners, securing three of the four sides together. The remaining side, a short one, was prevented from falling outward by a piece of furring, slightly nailed, at either end, to a 2 by 3 inch piece permanently spiked to either side of the form, near the top. At the bottom, on the lower sections, the end piece abutted against the piece of

furring nailed to the guides previously mentioned. With the 2 feet by 2 feet sections, the same method was used at the top, and a cleat, nailed to the form below, prevented the remaining side or end piece from falling outward. The pieces of furring were easily detached by a hammer, when the forms could be spread and drawn off the section of concrete.

The forms for the long section of the pier were also of 2-inch spruce plank, planed on the inside, the grain being vertical. Three sides were spiked together permanently. Planks 10 and 12 inches wide were used, 4 lengths of the 12-inch and 2 of the 10-inch being required to make the permanent portion. In addition there were enough pieces, 20 inches long and 2 inches in thickness, to make their combined width equal the height of the form. What might be called the sides of the form were composed of the planks 12 inches wide; and the back, of the planks 10 inches wide. On the front of each side a 2 by 3 inch piece, extending the length of each form, was spiked flatwise to the front of each of the side planks; one of the 2-inch edges being flush with the outside of the form, the other projecting 1 inch beyond the inside of the form. This formed a lip which prevented the pieces 20 inches long from falling out. They were put in place with the ends pressed against the lips. (See Plate II, Fig. 1.)

This allowed the concrete to be rammed as it was put in, and not from the top, which would have been very difficult. What might be called ramming was done with a spade, and consisted in keeping the coarser material away from the sides of the form. The concrete was so wet that it needed but little ramming.

To resist the outward pressure of the concrete, the forms were clamped by short pieces of joist drawn together by iron rods having nuts and washers. When the forms were to be removed, the clamps were unbolted and removed, the form pried open on the front sufficiently to allow the projecting inch of the 2 by 3 inch piece on each side to pass the concrete. The form was then pushed away from the pier, generally at the top first, and finally taken down. Usually a man went to the top of the pier, and with a small iron bar pried the form away from the concrete.

The centering for the roof between any 4 piers consisted of four quarter sections (model shown, scale 1 inch to 1 foot).

The frame was of one length of 3-inch spruce plank, 13 feet 6 inches long and about 10 inches wide, which was the widest that could be obtained, together with 2 pieces of 2-inch plank supported by the first-named piece and forming a sort of truss; also, two side pieces of 2-inch plank and 2 ribs of the same thickness. This frame was lagged with 1-inch matched spruce, planed on top.

A full-sized outline on heavy sheathing paper was made of the ellipse, having a span of 13 feet 6 inches and rise of 2 feet 9 inches. This represents the curve of the arch from pier to pier. The curve representing the arch from pier to pier on a diagonal line was also drawn. This is an ellipse of the same rise and a span of 19.09 feet. Of course only one-half of this ellipse was used.

Curves were drawn by using very light wire having sufficient strength, with as little liability to stretch as possible. This was found to be the great difficulty, and several attempts had to be made before a satisfactory result could be obtained. The proper length of wire was used, the ends being fastened to nails at points representing the foci of the ellipse to be drawn.

Other methods of drawing the ellipse might give a little greater accuracy, but the one used was the simplest and probably all that was needed. Wooden patterns were made of the various parts, and the lumber to form the centers was sawed at a local wood-working shop. The centers were put together at the reservoir by carpenters.

These quarter sections could be easily handled by four or five good men.

Four 4-inch by 6-inch spruce uprights were placed about each pier, upon the tops of which were placed caps not less than 2 inches in thickness. The lower ends of these uprights were supported by blocking, resting as far as possible on the pier foundations.

At the center between the piers, where the four quarter sections came together, a 6-inch by 6-inch spruce upright was used, supported at the bottom by blocking. (See Plate IV, Figs. 1 and 2, and Plate V, Fig. 1.)

The centers rested upon wooden wedges, placed upon the tops of the caps. These were of great use in setting the centers at the



FIG. 1.—STAGING USED IN REMOVING CENTERS.



FIG. 2.—PIERS AND GROINED ARCHES.

proper elevation and in taking them down. A leveling instrument was used in setting the centers at the proper elevation.

Four clamps, each made of two pieces of 2-inch spruce plank, a 4-inch separating piece, and a $\frac{3}{4}$ -inch bolt with washers and nut, were used on the under side of the frame of the centers, connecting adjoining quarter sections together and making the four sections practically one. (See Plate III, Fig. 2.)

It was found that without the 6-inch by 6-inch support at the center, the four sections thus united, and supported only at the four corners would carry a considerable load.

The $\frac{3}{4}$ -inch lagging was kept 1 inch away from the outside edge of the 2-inch plank, cut to form the curve from pier to pier, forming the 13 foot 6 inch span. This gave opportunity for nailing the 20-inch pieces of lagging which covered the space between one of the quarter sections and the one nearest, but not touching it. (See Plate IV, Fig. 1.) These lagging pieces were secured by small nails, sufficient to hold them in place while the concrete was being placed. In removing the centers these pieces had to be detached, and were usually left sticking to the under side of the arch till removed by a blow from a hammer, or pried off with a small bar.

When the centers were new, the concrete did not stick to them, and after being used the second time they were brushed with dead oil, which seemed to facilitate their removal.

The 4-inch by 6-inch uprights were braced by lines of 2-inch plank, extending from one slope to the opposite one. This prevented the upright from buckling, and also furnished support for a stage used to great advantage in placing and removing the centers. The centers were put together upon the bank and carried over those already placed and slid down to the staging at the desired point.

In removal, the centers were simply let down upon the stage and carried forward to their new position. No derrick or hoisting engine was used for any part of the work. (See Plate V, Fig. 1.)

The whole number of quarter sections of roof centers made was 185. If the entire roof had been centered at once, and no center used twice, 624 quarter sections would have been required, in addition to special work necessary between the regular quarter sections and the inside slopes of the reservoir.

DISCUSSION.

MR. F. W. DEAN. It has occurred to me that the concrete was rather rich for the purpose for which it was used, and I would like to ask Mr. Fuller if he could not have made it less rich.

MR. FULLER. Possibly. The piers were not of very great cross section, the load on them was quite heavy, between eighteen and nineteen tons to the square foot, at the bottom,— I suppose they would have stood more,—and the roof was only 6 inches in thickness at the crown. At the time the roof was covered it was done by driving on to it with 2-horse tip-carts which were well filled, because we had extra power for drawing them up the bank, so the horses could draw as much as could be piled on the carts. The filling was done to a considerable extent after freezing weather. The first earth that was put on was left very rough, after which considerable rain fell, and a cold spell followed, and the earth froze very rough indeed. A plowed field would not be as rough as that surface was, and as those teams went over that concrete, some of which had perhaps not been placed more than a month, and would go along and strike a hump of frozen earth and come down with great force, I felt that the concrete was none too rich. It seemed to me as though at times the teams would surely go through, but none of them did. I suppose something might have been saved, but I hardly think I should have wanted to make the concrete any less rich. It really seemed wonderful that six inches of concrete — of course it was thicker on either side of the crown of the arch — it seemed almost marvelous that that concrete could stand such heavy teaming over it. If the surface had been smooth, or if there had been a few inches of yielding material under it, it would have been different, but it was frozen solid and was as rough as it could be, and yet those teams drove over it and went up and down with very heavy loads—the carts, of course, having no springs—without apparently making any impression on it.

MR. LEONARD METCALF.* Mr. President, I have been very much interested in Mr. Fuller's paper to-night, as I have followed with great interest the growing use of the groined arch as a covering for filters and reservoirs, and the developments which have

* Civil Engineer, Boston, Mass.

taken place in it since it was first introduced into this country by Mr. William Wheeler of Boston, a member of this Association, in the Ashland, Wis., slow sand filter plant in 1895, and that of Somersworth, N. H., in 1896.

At the time of the construction of the latter plant, I had occasion to figure the quantities of masonry involved in this roof, and developed a series of mathematical formulæ therefor, which was afterwards amplified and presented in a paper before the American Society of Civil Engineers.*

Thinking that the matter might perhaps be of more than passing interest to the members of this Association, I have prepared a table of the masonry groined arch roofs which have chanced to come to my notice, giving not only a description and dimensions of the various structures, but a computation of the mean thickness of the masonry resulting from this form of construction and the cost of the roof, where such figures have been published.

It will be noticed that while there is marked similarity in the general dimensions, there have been some interesting improvements in the later work which have resulted in materially reducing the quantity of masonry or the resulting mean thickness of roof, without injury to the structure, it is believed. The most noticeable and important of these changes is that of making a depression in the masonry over the pier supporting the roof. This depression, in the majority of cases, has been in the form of an inverted pyramid of parabolic section, which is singularly well adapted for use with the elliptical groined arch intrados, though the inverted cone or pyramid has also been used. The amount of masonry to be saved in this way varies from about 10 to 30 per cent.

In some smaller roofs, as, for instance, at Clinton, or the sewage storage tank at Concord, 100 feet and 57 feet in diameter, respectively, and some others which were small, the number of piers was comparatively small, and consequently the total amount of masonry to be saved in that way was also comparatively small. Under those circumstances the actual saving to be made by depressions in the masonry over the piers is little, not only on account of the small amount of total masonry involved, but also on account of the fact that the cost of the centering is a very

* See Trans. Am. Soc. C. E., June, 1900.

DATA RELATING TO GROINED ARCHES IN THE UNITED STATES.

DATE.	LOCATION.	ENGINEER.	DESCRIPTION.	Depth of earth cover.	CONCRETE MIXED.
1895	Ashland, Wis.	Wm. Wheeler	Filters net area $\frac{1}{2}$ acre. Intrados ellip., extrados plane, 2 layers flat brick backed with concrete.	2'-0"	1: 2½: 5
1896	Somersworth, N. H.	Wm. Wheeler.	Two filters, total net area $\frac{1}{2}$ acre. Intrados elliptical extra. plane. 1 layer of br. on edge backed with concrete.	2'-6"	1: 2½: 5
1897	Wellesley, Mass.	F. C. Coffin	Reservoir 80' int. diameter. Intrados elliptical ext. plane.	2'-0"	1: 2½: 5
1898	Louisville, Ky.	Chas. Hermany	Reservoir 154,739 sq. ft. net area. Concrete reinforced with steel. Intrados and extrados segmental.	6"	1: 2: 4
1899	Concord, Mass.	Leonard Metcalf	Sewage reservoir 57 int. Diameter. Intra. ellip. extra. plane.	2'-6"	1: 2: 5
1899	Albany, N. Y.	Allen Hazen	Filters 8 beds of 0.7 acre each. Intra. ellip., extra. conical.	2'-0"	1: 3: 5
1899	Clinton, Mass.	F. P. Stearns	Sewage reservoir 100' Int. Diameter. intra. ellip., extra. plane.	4'-6"	1: 2½: 4
1899	Superior, Wis.	Allen Hazen	Filters and reservoir, total net area $\frac{1}{2}$ acre, conical.	2'-0"	1: 3: 5
1901	Philadelphia, Pa. Lower Roxboro'h	John W. Hill	Filters 5 of 0.537 acre each. Also filtered water basin 153'x190'.	2'-0"	1: 3: 5
1902	Milford, Mass.	Leonard Metcalf	Filters 2 of $\frac{1}{2}$ acre each. Intra. ellip. extra. parabolic.	1'-6"	1: 2½: 5 1: 3: 5
1902	Philadelphia, Pa. Upper Roxboro'h	John W. Hill	Filters 8 of 0.7 acre each. Also filtered water basin 238'x319'.	2'-0"	1: 3: 5
1902	Natick, Mass.	Frank L. Fuller	Reservoir. Intra. ellip. extra. plane. Coag. basin and reservoir.	2'-0"	1: 2½: 4½" 1: 2½: 4½"
1903	Ithaca, N. Y.	Allen Hazen	Intra. ellip. extra. parabolic.	2'-0"	1 bbl. 39c.f.:17c.f.
1903?	Proposed for Lawrence, Mass.	Morris Knowles	Filter. Intra. ellip. extra. parabolic.	3'-0"	?
1903	Yonkers, N. Y.	Allen Hazen	Reservoir. Intra. ellip. extra. parabolic.	4'-0"	1: 2.9: 5
1903 Begun	Watertown, N. Y.	Allen Hazen	Coag. basin and reservoir. Intra. ellip. extra. parabolic.	2'-0"	1: 2.9: 5
1903	Brookline, Mass.	F. F. Forbes	Reservoir all concrete. Intra. ellip. extra. plane.	2'-0"	1: 2: 4
1903	Philadelphia, Pa. Belmont	John W. Hill	Filters 18 of 0.74 acre each. Intra. ellip. extra. parabolic.	2'-0"	1: 3: 5
1903	Philadelphia, Pa. Belmont	John W. Hill	Filtered water basin 382x396. Intra. ellip. extra. parabolic.	2'-0"	1: 3: 5
1903 Begun	Philadelphia, Pa. Torresdale	John W. Hill	Filters 33 of 0.75 acre each. Intra. ellip. extra. parabolic.	2'-0"	1: 3: 5
1903 Begun	Philadelphia, Pa. Torresdale	John W. Hill	Filters 22 of 0.75 acre each. Intra. ellip. extra. parabolic.	2'-0"	1: 3: 5
1903 Begun	Philadelphia, Pa. Torresdale	John W. Hill	Filt. water basin 602x762. Intra. ellip. extra. parabolic.	2'-0"	1: 3: 5
1903 Begun	Washington, D. C.	Col. A. M. Miller	Filters Nos. 1 to 24.	2'-0"	1: 2.9: 5
1903 Begun	Washington, D. C.	Col. A. M. Miller	Filters Nos. 25 to 29.	2'-0"	1: 2.9: 5
1903	New Milford, N.J.	Hering & Fuller	Clear water well under Mech. filters 2 sec. 47x148. ⁶	none	
1903	New Milford, N.J.	Hering & Fuller	do. do. ⁷	none	
1903 Begun	Washington, D. C.	Col. A. M. Miller	P. W. Reservoir.	2'-0"	1: 2.9: 5

¹ Cost column covers cost of masonry only from springing line of roof. Earth cover and engineering not included unless so stated. ² Earth cover, etc., included. Total exclusive of engineering only (10%±) See text. Steel reinforcement. ³ Including filling, manholes, etc., but excluding en-

PREPARED BY LEONARD METCALF, 14 BEACON STREET,
BOSTON, MASS., DECEMBER 1, 1903.

ARCH.			Depression over pier, inches.	Pier Section at spring- ing, inches, and area, sq. ft.	Volume saved by de- pression in cu. yds. and equal depth in in.	Mean thickness of roof, inches.	Cost per square foot, Dollars.	Pier load tons per sq. ft. above springing line. Concrete at 150 lbs. Brick at 130 lbs. Earth at 110 lbs. Snow 15.	Intrados R = $\frac{(\text{Span})^2}{8 \text{ Rise}} \pm$	Intrados (semi span) ² + (rise) ² R = $\frac{1}{2} \text{ Rise}$.
Span.	Rise.	Cr'n Th'kn's.								
15'-9"	3'-6"	6"	none	28×23=4.42 28½×24=4.73 brick	none	11.7"		12.5	8.9'	10.6'
16'-0"	4'-0"	6"	none	34½×34=8.15 granite	none	13	\$0.47	9.7	8.0	10.0
12'-0"	2'-6"	6"	none	24"×24"=4.0 brick	none	10.3	0.225	8.9	7.2	8.5-
19'-0"	3'-9.6	6"	27.6"	Dia. 3.4'=9.0	5.45=3.7"	11.7	0.61 ²	5.8	(11.9)	(13.8)
12'-9"	3'-0"	6"	none	24"×24"=4.0 brick	none	11.0	0.38	11.7	6.8	8.3
11'-11"	2'-6"	6"	6"	21×21=3.06 brick	0.93=1.63	8.5	0.182 0.277 ³	11.0	7.1	8.4-
12'-0 7/8"	2'-6"	12"	none	30×30=6.25 25×25=4.33 brick	none	16.8		12.2 17.7	7.3	8.5
12'-0"	2'-6"	6"	6"	20×20=2.77 brick	0.93=1.63	8.4	0.29	12.0	7.2	8.5-
14'-0"	3'-0"	6"	21"	22×22=3.36	2.7=3.5	7.3		13.3	8.2-	9.7
14'-0"	3'-0"	6"	18"	24×24=4.0	2.37=3.0	7.9	0.36 ⁴	9.8	8.2-	9.7
14'-0"	3'-0"	6"	21"	22×22=3.36	2.70=3.5	7.3		16.8 ⁵ 13.3	8.2-	9.7
13'-6"	2'-9"	6"	none	20×20=2.77	none	10.2	0.40	15.1	8.3	9.7
10'-6"	1'-6"	6"	10 1/4"	18×18=2.25 17×17=2.01	0.75=1.70	6.78		10.9 & 12.2	9.2	9.9
13'-2"	2'-9"	6"	18"	22×22=3.36	2.08=3.0	7.5		15.6	7.9	9.2
10'-0"	1'-6"	6"	9 3/4"	16 3/4×16 3/4=1.96	0.65=1.6	7.0		18.5	8.3	9.1
10'-0"	1'-6"	6"	10"	18×18=2.25	0.68=1.7	6.9		9.9	8.3	9.1
12'-0"	2'-6"	6"	none	20×20=2.77	none	10.1	0.40±	12.2	7.2	8.4
13'-5"	3'-0"	6"	2"	22×22=3.36	2.51=3.5	7.3		12.4	7.5	9.0
14'-0"	3'-0"	6"	21"	22×22=3.36	2.70=3.5	7.2		13.3	8.2	9.7
14'-0"	3'-0"	6"	21"	22×22=3.36	2.70=3.5	7.2		13.3	8.2	9.7
13'-2"	3'-0"	6"	21"	22×22=3.36	2.43=3.5	7.4		12.0	7.2	8.7
14'-0"	3'-0"	6"	21"	22×22=3.36	2.70=3.5	7.2		13.3	8.2	9.7
12'-2"	2'-6"	6"	17"	22×22=3.36	1.70=2.8	7.3		9.7+ sand stored	7.4	8.6
11'-10"	2'-6"	6"	17"	22×22=3.36	1.63=2.8	7.4		9.1+ sand stored	7.0	8.2
9'-8" x 11'-8"	2'-6"	8"	none	24×24=4.0	none	11.7		30±?	4.7 6.8	5.9 8.1
11'-8" x 12'-0"	2'-6"	8"	none	24×24=4.0	none	12.3		30±?	6.8 7.2	8.1 8.4
15'-6"	3'-6"	6"	24 7/8"	30×30=6.25	4.0=1.5	7.9		8.7+ storage	8.6	10.3

gineering. ⁴Cost per square foot is estimated from force accounts; contractor's price was less (poor management). ⁵Including sand stored upon roof. ⁶1/8 of clear well with these arches. ⁷1/2 of clear well with these arches.

large proportion of the total cost of the masonry roof. If, on the other hand, the centering may be used over and over again, if the area is large enough, as was the case in the Albany work and the Philadelphia work, — and I think Mr. Fuller said in the Natick work. — the proportionate cost of the centering is not so large and the saving which will result from the depression over the piers is greater of course; while in the smaller structures, where the cost of centering is larger proportionally, the saving is proportionally smaller. It will generally be found that a decided net saving will be effected.

Each case, however, must be decided on its own merits, and various considerations may govern the engineer in his choice of design. Thus, the disadvantageous character of the ground in which the structure is built may make it desirable to have the greater stiffness and beam action resulting from building the extrados as a plane. Again, the area to be covered by the roof may be so small as to make the actual saving by depressing the roof over the piers insignificant. Or, proximity to other structures, with resulting unequal distribution of loading of the ground about the structure, or lack of homogeneity in the material surrounding it, may make the element of beam action in the roof of greater importance. Or, the necessity of storing sand upon the roof for lack of other room may make greater strength necessary; or, the side walls may be designed as beams to be built of concrete with embedded steel, as in the clear water basin and sedimentation tank which has just been completed at Ithaca, N. Y., — in which case the roof must act not only as an arch, but also as a beam to take the thrust coming from the walls; or questions of drainage may be of primary importance.

For these reasons, it is by no means safe to criticise different designs simply on the basis of the amount of masonry involved, without knowing fully the local conditions attending the work. Moreover, in glancing back at the old work, the first of which was constructed of brick masonry, re-enforced with concrete, the fact must not be lost sight of that the work was novel at the time of its construction, and that the excellence of concrete as a building material, when judiciously handled, had not been so well demonstrated as it has by the more general use in recent years; the price of cement was also considerably higher than to-day.

It is interesting to note that in the later designs, not only have depressions been made over the piers, but the sections of the piers have been decreased, with resulting increase in unit load per square foot borne by the pier; and the amount of cement used, or the richness of the concrete, has been materially decreased.

Moreover, in some of the recent designs circular piers have been used or proposed in place of the square ones, with square capitals upon them. While the writer was of the opinion that the use of the latter form would probably not result in any material saving in cost, on account of the greater difficulty in forming the capital for the column, he was interested to hear that in the recent plans for the proposed filter plant of Pittsburg, Pa., not yet built, quotations were obtained upon both forms of piers, and it was found that the unit prices were substantially identical, which would result, if not in an actual saving of cost, at all events in a better distribution of the material in the pier.

I should be very much interested to hear from Mr. Fuller in regard to the reasons which led to his adoption of the horizontal surface in this case, for I have no doubt he considered the saving which might have been effected in the way I have indicated.

The first arches which were built, those at Ashland, Wis., which, as I have said, were built in 1895, had a span of 15 feet 9 inches; a rise of 3 feet 6 inches; a crown thickness — as has been the case in almost all of these arches — of 6 inches. The pier section of the Ashland filter was about 4.4 square feet; that is, it was 2 feet 4 inches by 1.9 feet. This resulted in a net load on the pier, — figuring on the basis of concrete at 150 pounds per cubic foot, brickwork at 130 pounds, earth at 110 pounds, and snow at 15 pounds per square foot, — or a unit load at the springing line (not at the base of the pier) of $12\frac{1}{2}$ tons per square foot. The surface of that arch is a plane surface. The arch was built with two courses of brick laid flat, that is, on the bed, covered with concrete, bringing the extrados up to a level surface, and giving six inches of masonry at the crown of the arch. That resulted in a mean thickness of the roof, figuring all the masonry above the springing line, and not making any deduction for manholes, of 11.7 inches. The concrete used was mixed in the proportions of $1:2\frac{1}{2}:5$.

At Somersworth the proportions of the concrete were the same; the span was 3 inches longer, that is, 16 feet; the rise was 4 feet; the piers were built of granite, — whereas in Ashland they were built of brick, — and the section contained 8.15 square feet. The net load resulting, with an earth filling of $2\frac{1}{2}$ feet in depth, was 9.7 tons per square foot. There resulted a mean thickness of about 13 inches of masonry. In that case the roof was constructed of one course of brick laid on edge, surmounted by a layer of concrete, bringing the extrados surface to a horizontal plane.

These filters were built, of course, before concrete was used as it is to-day. They were the first roofs of the kind that were built in this country; they were, indeed, substantially the first roofs of the kind that had been built anywhere. Of course the groined arch had been used in architectural work and in some large spans abroad, but not in quite this way.

The next structure of the kind which was built was the Wellesley reservoir, by Mr. Coffin, in 1897. It was circular, only 80 feet in diameter, small, you see, with the same proportions of cement, sand, and stone in the concrete; with a span of 12 feet, a rise of $2\frac{1}{2}$ feet, a pier section of 4 square feet, that is, 2 feet by 2 feet of brick, resulting in a unit load of 8.9 tons, and a mean thickness of 10.3 inches. You see the mean depth of the masonry is decreasing. This was moreover the first structure of the kind in which the roof was built entirely of concrete.

Then there was built in 1899 the sewage storage basin, so-called, at Concord, with a mean thickness of 11.7 inches and a pier load of 11.7 tons. In that case the surrounding material was exceedingly bad, the structure was of small dimensions, and there was a pumping station with comparatively heavy loads right beside it; for this reason no depression was made in the roof masonry over the piers.

In 1898-9 the Albany filter plant was built by Mr. Hazen, whose resident engineer, Mr. William B. Fuller, is here to-night, and will perhaps tell you what sort of service or treatment some of those arches received. The proportions of the concrete were 1:3:5, as I remember, with a span of 11 feet 11 inches and a rise of $2\frac{1}{2}$ feet, with piers 21 inches by 21 inches, giving a mean depth of 8.5 inches and an average load of 11 tons.

Then followed the Clinton sewage reservoir, built by the Metropolitan Water Board in 1899. The arches had a very heavy load over them, the depth of earth being $4\frac{1}{2}$ feet. The bottom on which they were constructed was exceedingly bad, with possible danger of floating the structure, and evidently they were anxious about the loads on the arches and the character of the material surrounding the structure, because the proportions of the concrete were very rich, being $1:2\frac{1}{2}:4$. The crown thickness was 12 inches. This gave a mean depth of 16.8 inches and a load at the springing of 12.2 tons and at the minimum section of the piers, just below there, of 17.7 tons.

Then followed the filters at Superior, Wis., built in 1899 by Mr. Hazen, in which the mean thickness was 8.4 inches and the load 12.0 tons.

In 1901 came the Philadelphia plant. The proportions of concrete were there $1:3:5$, the mean thickness was 7.3 inches, and the pier load 13.3 tons to the square foot. In that case the depression over the pier was 21 inches, and the saving was approximately 2.7 yards of masonry to a pier, which was equivalent to $3\frac{1}{2}$ inches over the section covered by the pier. You see how much that means. As I remember it, it figures out something over 30 per cent. of saving.

Then came the Milford plant, which was built in 1902, in which the depression was 18 inches and the mean thickness 7.9 inches and the load 9.8 tons per square foot. I might say that in that case there was very little room about the filter for storing the sand, and we thought that possibly it might be necessary to store the washed sand from the filter on top of the filter roof itself, and so figured on a depth of four feet of sand spread over the filter roof, which brought the load up to 16.8 tons per square foot. It was for that reason also that the piers were made a little heavier than originally designed, that is, 2 feet square, while my original plans called for an 18-inch pier.

Then followed the Upper Roxborough plant in Philadelphia, which was identical with the Lower Roxborough plant, giving 7.3 inches mean depth.

Then came the Natick reservoir, with, as I have figured it, a mean thickness of roof of 10.2 inches, and a load of 15.1 tons per square foot at the springing line — not at the base of the pier.

And last of all, is the Ithaca plant, designed by Mr. Hazen which has just been completed, and about the dimensions of which I am a little in doubt. My impression is that the depression over the piers is about 6 inches (actually $10\frac{1}{4}$ inches). If that is the case, the average depth in thickness of the masonry would be $7\frac{1}{2}$ inches (actually 6.8 inches) and the load from 10.9 to 12.2 tons per square foot.

It is interesting, too, I think, to see the decrease in the section of the piers and the resulting increase in the unit loads. Engineers generally, I think, have not come yet to the heavy unit loads on concrete piers that some of the concrete construction companies have used, one or two of which, I remember hearing, amounted to 33 tons to the square foot on piers 12 by 12 inches. Of course that seems entirely feasible if the material is good, and if you are perfectly sure of your work, in view of the concrete tests that have been made at the Watertown Arsenal and elsewhere.

I hope Mr. William B. Fuller will say something to us about the Albany plant, particularly in view of what Mr. Frank L. Fuller has said about driving teams over the groined arches. My recollection is that I saw a 5 or 7-ton roller in use on the roof of the Albany filter plant, and I do not think that the concrete was injured by it. He knows the facts.

MR. LEONARD METCALF (by letter).* The writer has ventured to supplement his discussion of Mr. Fuller's paper by certain additional data which may be of interest in bringing information down to date, and as being of historical value in the study of the development of the groined arch roof in engineering structures in the United States. In this he has been materially assisted by contributions from Mr. Charles Hermany of Louisville and Mr. Allen Hazen and Mr. John H. Gregory of New York, who have furnished him with new material and have kindly consented to the publishing of some of the interesting facts mentioned by them relating to the construction of plants designed by them.

In comment upon the table, one or two facts should be mentioned. The "Mean Thickness of Roof, Inches" is figured on the basis of the amount of masonry above a horizontal plane passing through the springing line of the roof arches and contained within the area covered by pier units. No account is taken of the

* Received December 11, 1903. — EDITOR.

masonry in the pier below this plane or of the masonry in the floor. No allowance is made for the increased amount of masonry used in the barrel or the cloistered arch along the walls surrounding the area covered by pier units, as the pier unit area was thought to be the better unit of comparison. Neither was allowance made on account of manholes or sand runs. These elements — manholes, sand runs, barrel and cloistered arches, — will be found in ordinary large units to increase the average thickness of the roof above the springing line, as determined from the pier units, by about $\frac{1}{2}$ to $1\frac{1}{2}$ inches.

The "Cost of the Roof per Square Foot" in general covers only the cost of the masonry, including therein materials, labor, centering, and removing centering, etc. (above springing line of roof), but does not include the cost of earth covering and of engineering.

In the last two columns has been computed a function of these arches which have been built, a function that many engineers must have noticed, though, so far as the writer knows, Mr. Hazen was the first to specifically allude to it in a letter to him dated October 6, 1903. In this Mr. Hazen writes:

In your table of vaulting there is one point of some interest to me; namely, that the circle having the same curvature as the ellipse at the top, the radius of which is obtained by squaring the span and dividing by the rise, is, for all figures listed in your table, somewhere nearly a constant; at least it varies a good deal less than any of the other dimensions do. This indicates approximately a constant thrust and a constant strength of vaulting per square foot of area when it is computed acting entirely as an arch.

This relation, which briefly consists in finding the radius of a circle passing through the crown and the springing lines of the elliptical groined arch, is, of course, one long known to railroad engineers, who have made use of the approximate formula:

$$\text{Middle ordinate} = \frac{\text{Chord}^2}{8 \times \text{Radius}}$$

from which, by transposition, we have

$$\text{the Radius} = \frac{\text{Square of Span}}{8 \times \text{Rise}}$$

This value, figured by the writer and shown in the left of the two columns mentioned, led him to compute the more exact value

of this radius from the relation of similar triangles, which gives the formula:

$$\text{Radius} = \frac{(\text{Chord of semi-span})^2}{2 \times \text{Rise}} = \frac{(\text{Semi-span})^2 + (\text{Rise})^2}{2 \times \text{Rise}}.$$

While both of these values are empirical,—for the arches have generally been segmental, not elliptical,—they are of interest and serve as guides to judgment in design. The average value of the radius (shown in the right column) as determined by omitting the Louisville arches—which contained embedded steel—and the New Milford, N. J., arches,—which have an abnormally heavy superposed load, a mechanical filter plant,—is found to be

$$R = 9.17 \text{ feet,}$$

while the extremes of conservative and radical practice (though in the writer's opinion the radical class of to-day will become the conservative class of the next decade), show approximate values of $R = 8.5$ and $R = 10$ feet.

Mr. Hazen writes in regard to the Albany filter roof:

I see at Albany the extrados is marked parabolic. This was true of the outside and cross walls, but the depression over the piers was made conical. The cone, however, did not start exactly at the summit, but at such a point as not to reduce the thickness of the arch below six inches, and, in fact, the minimum due to the cone was a little more than this figure. From my final estimates the volume of the depression was 25.219 cubic feet. The volume equal to a square six inches thick was 93.389 cubic feet, and the volume of the vaulting from the pier up to the bottom of the 6-inch slab was 64.065 cubic feet, making the exact volume over each pier 132.235 cubic feet, which corresponds to a thickness of about 0.71 foot.

Another computation which I made February 9, 1899, gives:

Reduced thickness of vaulting over piers in filters	0.71 foot
Over piers in pure water reservoir (no depression)	0.84 „
Outside walls	0.81 „
Cross walls	0.90 „
Other cross walls	0.83 „
Outside corners	1.06 „
Inside corners	1.54 „
Manholes (Distributed over whole area)	0.029 „
Sand runs, about 0.5 foot extra over gross area of same.	
Average thickness of vaulting, including all extras on	
net area	0.77 „

I see that in discussing your paper on "Vaulting" I gave the reduced thickness as 0.78. This latter computation was made some months later, and I

do not find memoranda of it, but I do find that the total quantity of concrete in the vaulting as allowed in the final estimate overran the amount which I estimated in my computation of February 9, 1899, by about one per cent.; so that the figure given, namely, 0.78, is apparently the correct one.

Apparently this was the first time that the depression over the piers was used, and I do not think it occurred to us to make it parabolic. We did make some designs for curves, but my recollection is that we thought the conical surface would be a good deal easier to build and would accomplish substantially the result to be reached as well as a curved surface.

The sections of the vaulting over the outside and cross walls vary a little in different parts of the work. I have a large scale plotting of these sections as they were actually built, which I had made at the time, partly for the purpose of the final estimates and partly as a permanent record of exactly what was used.

For the amount of depression that we used at Albany, I still think the conical depression is better than the parabolic, but for the deeper cuts which have since been made it will not do, and I have thus used the parabolic curves on all my later designs.

Upon the Superior plant he says:

The depression over the piers at Superior is the same as at Albany, and amounts, as I compute it, to 1.63 inches instead of 1 inch, with a corresponding reduction in the distributed thickness of the vaulting.

In regard to the Yonkers and Watertown, N. Y., plants, he writes:

The Watertown piers were made a little larger relatively than usual, because they were rather high, and the Yonkers piers were considerably smaller than usual, being about normal for the 2-foot cover. Putting the extra weight on the vaulting, of course, runs up the load per square foot a good deal. The increased thickness of covering in this case was an afterthought, which facilitated some other matters, and the size of the piers was not changed. At Yonkers the fill was made 4 feet, the extra depth being partly as a dike to protect against floods and partly as a load to prevent possible floating with high ground-water and with the reservoir empty.

While the smaller piers at Yonkers are undoubtedly amply safe, the saving in material does not amount to much, and next time I should make them uniform with the others. The curve of the roof is identical in the two designs, but there is a slight difference in the drop to correspond with the longer span at Watertown.

The above dimensions are the nominal dimensions. In actually laying the thing out I usually make the forms slightly shorter than the schedule, so as to give the contractor a little come and go. This facilitates the work greatly, and the increased amount of concrete does not amount to much. When the piers are just right or are out in the wrong direction, of course this

leaves a crack between the top of the pier and the center, which ought to be plugged before the concrete is placed.

In comment upon the Washington filters, Mr. Hazen writes:

While it is not intended to store sand on this vaulting, it was intended to be strong enough so that the vaulting could be loaded pretty freely in this respect, and so that light tracks could be laid upon it.

Mr. Charles Hermany, engineer of the Louisville, Ky., Water Company's water purification station at Crescent Hill, Ky., gives the following interesting and exceedingly valuable detailed account of that work:

The year is given as 1898 because the design and dimensions were determined then and afterwards carried out without deviation. The work was completed in 1900.

Both the arches and columns are stronger than necessary, were they only to support themselves and the earth filling. This has been proven by building upon the groined arches a concrete bed 8 inches thick over the crown, in which a track is built of standard steel rails, 80 pounds to the yard, and loaded freight cars pushed over it with a combined dead and live load (car and freight) of five tons to the car-wheel without visible effect upon arch or columns. When designing these arches it was not apprehended that it would be desirable or necessary to run cars across them.

Great misgiving was manifested by contractors as to the practicability of building reliable columns of this description. The successful and satisfactory building of them proved to be one of the easiest and simplest tasks connected with the reservoir.

The concrete was machine-mixed, but all the manual labor was performed by crude and unskilled men, with which difficulty was experienced in satisfactorily building the arches; it was accomplished only by constant and vigilant engineering supervision. With the experience gained in this work, entirely satisfactory results could be obtained with reduction in both volume of concrete and cost of construction.

The solidifying of the concrete by tamping was done by hand, in layers of about 4 inches in thickness at a time. Better results have since been accomplished by reducing the thickness of layers and using pneumatic tampers.

MEMORANDUM OF FEBRUARY 8, 1902.

THE CLEAR WATER RESERVOIR AT THE LOUISVILLE WATER COMPANY'S WATER PURIFICATION STATION AT CRESCENT HILL, KY.

	<i>Sq. ft.</i>
1. Total area of quadrangular space covered by the outside dimensions of the structure	180 740
2. Area covered by the four retaining walls	18 541
3. Area covered by the three division walls	4 460
4. Area covered by 256 columns supporting the groined arches	3 000
5. Aggregate area of water surface in the four compartments	154 739
Total	180 740

which water surface is the area roofed over by the groined arches. The groined arches are 340 in number, 270 of which are square, 22 by 22 feet span between centers of columns, and 70 arches are in one direction of 22-foot span, and at right angles thereto of variable span, — both greater and smaller than 22 feet, — owing to the quadrangular plan of the reservoir not being a square but a trapezoid.

In the following table are given the items which comprise the cost of constructing the arched covering to the clear water reservoir, subdivided into ten different classifications of material and work.

TABLE.

		<i>Per sq. ft.</i>
1. 2446.93 c. y. Portland cement 1-2-4 concrete in columns,		
at \$7.10,	$\frac{\$17,373.20}{154\ 739} =$	\$0.112
2. 333.32 s. y. Portland cement 1-2 mortar in columns, at		
29 cts.,	$\frac{\$96.66}{154\ 739} =$	0.001
3. 7484.11 c. y. Portland cement 1-2-4 concrete in arches, at		
\$7.10,	$\frac{\$53,137.18}{154,739} =$	0.343
4. 978.13 s. y. Portland cement 1-2 mortar in arches, at 42		
cts.,	$\frac{\$410.81}{154\ 739} =$	0.003
5. 168 750 lbs. steel ribs in concrete arches, at $3\frac{1}{4}$ cts.,		
	$\frac{\$5,484.40}{154\ 739} =$	0.035
6. 7325.89 s. y. neat Portland cement mortar one-eighth inch		
thick plaster on columns, 23 cts.	$\frac{\$1,684.95}{154\ 739} =$	0.011
7. 18 444.87 s. y. neat Portland cement mortar one-eighth inch		
thick plaster on soffit of arches, 23 cts.,	$\frac{\$4,241.40}{154\ 739} =$	0.027
8. 3928.04 c. y. earth fill over arches, 30 cts.,	$\frac{\$1,178.41}{154\ 739} =$	0.008
9. 154 739 s. f. sodding, at $10\frac{1}{2}$ cts. per s. y.,	$\frac{\$1,805.29}{154\ 739} =$	0.012
10. Centers for arches and falseworks, \$9,000.00	$\frac{\$9,000.00}{154\ 739} =$	0.059
		<hr/>
		\$0.611
Less correction		0.001
Total cost per square foot of covering		<hr/>
		\$0.610

In the above, items 2 and 4 are for mortar used to interpose between successive additions of concrete, so as to make such additions adhere to each other.

The foregoing ten items of cost comprise the total amount paid by the Water Company to the contractor, to which wants to be added the cost of inspection and engineering supervision, which amount is not exactly known, but will approximate closely to ten per cent. of the cost.

MR. WILLIAM B. FULLER.* Mr. President and gentlemen: The strength of a concrete groined arch is very difficult if not impossible of calculation, as a satisfactory theory of the stresses in such a structure has not as yet been developed. Our knowledge of the strength of such groined arches is based, therefore, to a large extent, on their behavior under conditions of greater stress than ordinary conditions, and it is to be commended, therefore, that the author has described the treatment in this respect, which his arches have received. The speaker also has had cases on his own work where groined arches have been accidentally exposed to heavier loading than they were expected to carry, without any bad effects.

It seems to be a universal practice to make the thickness of the crown of the arch six inches, probably because in practice this is about the minimum thickness of concrete which can be placed with ordinary labor and with the same concrete as used in the more massive part of the work. A less thickness at the crown would call for greater care in placing and small diameter stone in the concrete, which would increase the cost per cubic yard and thus possibly offset the saving in quantity. There is, however, no reason except this practical one why the crown of the arch should not be made much thinner.

Several years ago, while superintending the construction of concrete groined arches at the Albany Filter Plant, the speaker made up and tested the strength of a few small models. These tests indicated that a groined arch of about 13 feet span, $3\frac{1}{2}$ feet rise, and 6 inches thick at the crown, after being built thirty or more days, would safely sustain without any danger of fracture of the arch a load of brick piled on top of the arch 40 feet high. At Albany a three-ton road roller was repeatedly run over the arches previous to the placing of the dirt and within thirty days after the concrete was placed. At another time the contractor placed a derrick bringing a concentrated load of nearly two tons on about one square foot in the center of the arch. Heavily loaded two-

* Civil Engineer, New York, N. Y.

horse wagons drove over the arches in all directions with ut restriction, sometimes within two weeks of the placing of the concrete.

At Philadelphia a road roller weighing several tons and drawn by four horses was driven over an arch which had been cut along its crown so that it was simply a cantilever extending out from the piers about 7 feet; that is, this arch was built only to the line where the author explained that he stopped his concrete during a day's work. The centers were removed and the roller passed over the half arch about thirty days after the concrete had been placed. An illustration of this is being used by one of the cement companies for advertising purposes.

The speaker would suggest a few improvements in relation to the author's centering which he has observed as in use at Philadelphia. Instead of placing four 4-inch by 6-inch posts at each pier extending from the floor of the filter to the under side of the centering, a great saving can be made in lumber by simply clamping a collar around the top of each pier on which the centers rest directly, without using any posts whatever. Instead of using 6 pieces of centering at each groin unit it would be better to make this unit in four parts, the lines of division extending square across from center to center of piers and diagonally from corner to corner of piers; by this method only one post is needed, that at the intersection of the diagonals from each pier, for holding up all four centers, each center resting on the clamps around each pier and on this center post. The economy of this method is particularly noticeable on deep and large reservoirs, as in such a case the centering can be used over and over again.

There is one point which Mr. Metcalf did not clearly bring out in relation to the saving in the concrete by leaving depressions over the piers. Depressions have been more frequently used over the piers of slow sand filter plants, because the water which would collect in such depressions can be run right down into the filters. In the case of a clear water reservoir, such as described by the author, it may not be desirable to run the surface water into the reservoir, and in such a case the depressions must be made water tight.

In Philadelphia, where depressions were left in the concrete

over the piers of the clear water reservoirs, such depressions were filled with clay puddle and of course the cost of the puddle should be deducted from the cost of the concrete saved in order to obtain the net saving.

MR. F. W. DEAN.* I think one interesting thing in regard to this matter is that it furnishes some additional illustrations of the frequency with which concrete construction is being carried on nowadays. It struck me, in listening to the description which Mr. Fuller gave of the groined arches, that they might be cast so as not to require any ramming whatever. That brought to mind having seen quite recently the process of building the Stadium at Harvard College, which is a large auditorium surrounding the football ground and designed to seat, I think, something like 50 000 persons. The architectural features were designed by McKim, Mead & White of New York, and the engineering features by the staff of the Lawrence Scientific School. There they have columns which I should think are some 20 inches square, made hollow, 4 inches thick; and the seats are being moulded just as cast iron is moulded, that is to say, they make patterns, as they would if they were making iron castings, then mix up sand and cement and pour it into the moulds, which are made in sand exactly as an iron mould is. They use for adding somewhat to the strength of these seats a framework of steel wires, which, I believe, where the wires cross each other at right angles, are welded by some process or other, and there they are casting thousands of those seats.

There is one thing I should like to know from Mr. Fuller, and that is, the gage of the stone which was used in his arches. I believe that was not mentioned by him.

MR. FRANK L. FULLER. As I remember, the specifications called for stone not over $2\frac{1}{2}$ inches in its longest diameter, but, as a matter of fact, I think a good deal larger stone was used, and I really see no objection to it. I think perhaps we had a small amount of stone which was 4 inches in diameter, stone which had been screened out of a gravel pit. It was good, clean, solid stone, and I was not very particular about the size of it.

I should just like to say a word in regard to another reservoir which I am building, where the walls are entirely of concrete,

* Mechanical Engineer, Boston, Mass.

2½ feet at the top and 3½ feet at the bottom, where the specifications allow 40 per cent. of stone to be bedded in the concrete. That wall is now finished, and apparently it is a good, sound piece of work. I do not know why in such piers as we are building, 20-inch piers and 24-inch piers, good, sound stone could not be put in. It would reduce the cost considerably, and I think would still give good work. The weight of the piers would not be reduced, and I do not see that their strength would be; and perhaps the same thing could be done in the filling over the piers. I know in certain work which is being done, for instance, the core wall of the Lynn dam, which was built partly last season and is being completed this season, or is now completed, a good many stone of considerable size were placed in that wall, which was, perhaps, — I cannot give the exact thickness, — 6 or 8 feet thick at a distance 15 or 20 feet below the top. I am not sure that these figures are exact, however.

MR. F. L. FULLER (by letter). While the writer has had no experience in the use of collars clamped to the top of concrete piers to support the centers, referred to by Mr. William B. Fuller, he has supported centers for lintel arches between brick piers successfully, by corbeling out the upper courses of bricks. The centering was, however, very light and the span short. These piers and arches supported a 12-inch brick ring, which in turn supported covering arches. Before the covering arches were built, however, the piers had been tied together at the top, so that no lateral movement was possible, and the Portland cement brickwork well set.

In the case of concrete piers and a groined arch roof, it would appear to the author safer to support the centers independently of the piers, as is the case where four 4 by 6 inch timbers resting on the pier foundations are used. It is often desirable to put the concrete roof in place before the piers have had time to become sufficiently set to bear the combined weight of centers and concrete roof.

It would seem that there might be a possibility of bending action, especially when the loading of the centering on different sides of the pier was unequal, which would be detrimental. It must be borne in mind that newly made concrete, especially with the increasing tendency to make it less rich and reduce the area of sections deserves careful treatment.

If, however, actual experience shows the method to be practical, there would be some saving in the cost of centering. At Natick centers were put in place around piers which were perhaps not more than five or six days old. In such cases, at least, it would seem best to the writer that these centers be supported independently of the piers.

By the time the centering is removed the piers have become solidified, and so joined together at the tops that, as in the case previously mentioned, there is no chance for lateral motion.

Further, these 4 by 6 inch timbers at each pier supporting the centers formed the means of also supporting a stage, as described on page 397, which was of great service.

Referring still further to Mr. Wm. B. Fuller's suggestions on page 413, the author would say that the four quarter sections of the Natick centering filled that part of the groin arch unit lying between the corners of the four surrounding piers. The four quarter sections of centering came together at the intersection of the diagonals from corner to corner of piers, and at this point required but one support, which at Natick was a 6 by 6 inch spruce timber, as described on page 396. The point of intersection of the diagonals, or the point at which the four quarter sections come together, is shown on Plate III, Fig. 2, the 6 by 6 inch support having been removed at the time the photograph was taken. The author's centering at Natick was bounded by three sides, and was simple in construction — but four pieces or sections were used within the square bounded by four piers. In addition were the 20-inch pieces of lagging, extending from one section to another and bridging the space by which they were separated. These short laggings were used over and over again, and were quickly put in place. The centering as used was very satisfactory in practice, and the author doubts whether much improvement could be made in it.

The sections or pieces of centering referred to by Mr. W. B. Fuller were apparently bounded by five sides, two of which were equal in length to one half of the side of the pier, and the other three, provided the span was the same, of the same length as those used at Natick. Apparently they would require a little more lumber, while the amount of lagging would be the same in either case.

In regard to depressions over piers, the author believes a saving can be made, especially in large roofs, and that in many cases the idea can and should be carried out. At Natick so little time was available to prepare plans and specifications in order that the work might be begun in time for its completion before winter that the question did not receive much consideration.

There are, of course, some objections to these depressions. Some care and attention are necessary on the part of both engineer and contractor or his workmen in forming them. If they are not uniform in size, for any cause, the volume of each depression must be measured, provided the work is done by contract. Probably not quite so wet concrete could be used. The depression forms a pocket for the collection of rain water which will probably find its way into the reservoir. This objection is, however, hardly worth considering, provided the covering material is free from anything liable to injure the water. If the roof were covered by means of teams, they could not drive over the tops of the piers with full loads, on account of the depressions, and a little more shoveling in leveling the top might be required.

PROCEEDINGS.

TWENTY-SECOND ANNUAL CONVENTION.

MONTREAL, September 9, 10, 11, 1903.

The twenty-second annual convention of the Association was held in Montreal on Wednesday, Thursday, and Friday, September 9, 10, and 11, 1903. The headquarters of the Association during the convention were at the St. Lawrence Hall, and the meetings were held in one of the large parlors of the hotel.

The following members and guests were registered:

MEMBERS.

S. A. Agnew, K. Allen, F. E. Appleton, M. N. Baker, L. M. Baneroft, J. E. Beals, J. F. Bigelow, F. E. Bisbee, George Bowers, E. C. Brooks, Fred. Brooks, L. Z. Carpenter, E. J. Chadbourne, Wm. F. Codd, M. F. Collins, M. A. Connell, F. H. Crandall, G. K. Crandall, J. W. Crawford, A. W. Cuddebaek, J. M. Davis, F. W. Dean, E. D. Eldredge, E. A. Ellsworth, August Fels, Murray Forbes, F. L. Fuller, W. B. Fuller, D. H. Gilderson, A. S. Glover, F. H. Golding, W. J. Goldthwait, J. W. Goodell, A. A. Gould, F. W. Gow, J. O. Hall, J. C. Hammond, Jr., J. D. Hardy, G. H. Hart, V. C. Hastings, W. E. Hawks, D. A. Heffernan, W. R. Hill, H. G. Holden, H. R. Johnson, Willard Kent, G. A. King, A. A. Knudson, C. F. Knowlton, E. S. Larned, H. A. Lord, H. V. Macksey, J. A. Marion, A. E. Martin, A. S. Merrill, F. E. Merrill, Leonard Metcalf, J. T. Miller, J. W. Moran, W. W. Patch, F. L. Northrop, W. Paulison, E. L. Peene, F. H. Pitcher, J.-B. Putnam, C. E. Riley, G. A. Sanborn, W. F. P. Sealy, E. M. Shedd, C. W. Sherman, M. A. Sinclair, G. H. Snell, J. F. Sprengel, G. A. Stacy, R. J. Thomas, H. L. Thomas, W. H. Thomas, J. L. Tighe, D. N. Tower, C. K. Walker, C. S. Warde, R. S. Weston, W. P. Whittemore, E. T. Wiswall, D. B. McCarthy, S. H. McKenzie. — 86.

ASSOCIATES.

Ashton Valve Co., by C. W. Houghton; Harold L. Bond & Co., by Harold L. Bond; Builders Iron Foundry, by F. N. Connet; Chadwick-Boston Lead Co., by Charles N. Fairbairn; Garlock Packing Co., by F. E. Putney; William H. Greenwood; Hersey Mfg. Co., by Albert S. Glover, J. A. Tilden and W. A. Hersey; International Steam Pump Co., by Samuel Harrison; Henry F. Jenks; Lamb & Ritchie, by A. P. Briggs; Lead-Lined Iron Pipe Co., by T. E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; H. Mueller Mfg. Co., by F. B. Mueller and W. L. Dickel; National Meter Co., by J. G. Lufkin;

Neptune Meter Co., by H. H. Kinsey and D. B. McCarthy; Norwood Engineering Co., by H. W. Hosford; Pittsburg Meter Co., by T. C. Clifford; Rensselaer Mfg. Co., by Fred S. Bates; Ross Valve Co., by William Ross; A. P. Smith Mfg. Co., by Anthony P. Smith, D. F. O'Brien, and John W. Strackbein; Sumner & Goodwin Co., by F. D. Sumner; Thomson Meter Co., by Henry C. Folger and S. D. Higley; Union Water Meter Co., by F. L. Northrop; United States Cast Iron Pipe & Foundry Co., by W. B. Franklin; Walworth Mfg. Co., by George E. Pickering; R. D. Wood & Co., by C. R. Wood. — 33

GUESTS.

Thos. Anderson, F. N. Collins, Mr. and Mrs. J. J. Desmond, Mrs. F. E. Appleton, Mrs. George Bowers, Miss Helen E. Bowers, Mrs. L. A. Buckman, R. G. Barnard, Mrs. V. G. Barnard, M. J. Dowd, Mr. and Mrs. Patrick Kelley, Mrs. Charles S. Proctor, Mr. and Mrs. E. H. Scribner, Miss Ellen M. Weaver, Frank L. Weaver, Mrs. Robert J. Thomas, Lowell; Thomas Burke, Mrs. J. F. Bigelow, Miss J. E. Fletcher, Mr. and Mrs. J. E. Warren, L. M. Hudson, Mrs. George A. Stacy, Marlboro; Mr. and Mrs. James P. Bacon, Mrs. E. C. Brooks, Cambridge; Wm. T. Barnes, J. M. Ham, Mrs. H. V. Macksey, Mrs. H. H. Kinsey, Miss Corabelle Robbins, Thomas P. Taylor, G. A. Titcomb, Boston; F. K. Begbir, Lindsay, Ont.; Richard Bradley, Branford, Conn.; Donald B. Brigham, Brookline; Mrs. J. E. Barlen, Mrs. J. Herbert Cushing, Mrs. Harold L. Bond, Malden; Joseph M. Birmingham, Hartford, Conn.; Susette C. Berry, A. W. Danforth, Lucy A. Danforth, Reading; Miss Stella Bent, Mrs. James A. Tilden, Hyde Park; Leroy Brown, Mr. and Mrs. Fred C. Gifford, Minnie A. Gifford, George W. Furbush, Waltham; Mrs. Wm. F. Codd, Nantucket; Charles E. Child, Mrs. George E. Pickering, Howard R. Pickering, Mrs. E. M. Shedd, Marion Merrill, W. M. Rea, Somerville; Mrs. George K. Crandall, New London, Conn.; Mark Dean, New York City; Harvey D. Eaton, Waterville, Me.; Mr. and Mrs. Wells Lathrop, Mr. and Mrs. A. M. French, Mrs. E. A. Ellsworth, Holyoke; Mrs. Horace G. Holden, Mr. and Mrs. M. J. Fletcher, W. H. Greenleaf, W. N. Gates, Chas. R. McQuesten, Nashua, N. H.; Mrs. Murray Forbes, Greensburg, Pa.; Mrs. Carrie L. Fuller, Paterson, N. J.; Miss Charlotte A. Gedge, Anderson, Ind.; Mrs. Fred W. Gow, Medford; Frank J. Gifford, Fall River; Henry Goldmark, Engineer Canadian Pacific Railway, Jas. M. Ward, R. R. Samuel, representing the *Canadian Engineer*, J. T. McCall, Mr. G. B. Mitchell W. C. Leitch, Superintendent Montreal Water & Power Co., Thomas W. Lesage, Assistant Superintendent Montreal Water Works, George Janin, Superintendent Montreal Water Works, Milton L. Hersey, M.Sc., City Analyst, Montreal, Canada; Emmanuel May, Valleyfield, Que.; Mrs. G. H. Hart, Maynard; Mrs. Wm. E. Hawks, Bennington, Vt.; F. E. Hunter, West Newton; Fred W. Ingersoll, Gloucester; Miss Kent, Woonsocket, R. I.; Mrs. Willard Kent, Narragansett Pier, R. I.; Arthur C. King, Taunton; Mrs. Harry A. Lord, Odgensburg, N. Y.; Mrs. D. B. McCarthy, George H. McCarthy, Miss Edith McCarthy, Waterford, N. Y.; Mrs. Mary Folger Wells, Miss Julian, Brooklyn, N. Y.; Walter E. Lautz, Secretary Pekin Water Works Co., Pekin, Ill.; Mrs. S. H. McKenzie, Southington, Conn.; Mr. and Mrs. Michael Walsh,

Mrs. Edward L. Peene, Yonkers, N. Y.; Mrs. W. Paulison, Passaic, N. J.; Mrs. Alice W. Hatch, South Framingham; Mrs. J. P. Putnam, Westboro; Lawrence P. Stanton, Alden Webb, Beverly; Howard Smith, Mrs. G. W. F. Smith, Mrs. W. F. P. Sealy, G. W. F. Smith, Potsdam, N. Y.; Mr. and Mrs. Phil S. Smith, Montpelier, Vt.; Mrs. Mary C. G. Sprenkel, Mrs. Julia A. Sprenkel, Miss Louise Sprenkel, Miss Ella Sprenkel, York, Penn.; Mrs. C. W. Small, Portland, Me.; Mr. and Mrs. Harry F. Thomas, Saratoga Springs, N. Y.; Mrs. Wm. H. Thomas, Mrs. Harry I. Thomas, Hingham; Mrs. D. N. Tower, Cohasset; Mrs. John O. Fall, Quincy. — 129

SUMMARY OF ATTENDANCE.

Members	86
Representatives of Associates	33
Guests	129
	<hr/>
	248
Counted twice	1
	<hr/>
Total attendance	247

WEDNESDAY, SEPTEMBER 9.

The convention was called to order at 11 A.M. by President Charles K. Walker, who introduced Mayor James Cochrane of Montreal. The Mayor spoke as follows:

ADDRESS OF WELCOME BY MAYOR COCHRANE.

MAYOR COCHRANE. *Mr. President, Ladies and Gentlemen,*—It gives me great pleasure to welcome to our city so many people from the New England States, and especially to meet so many representatives of water works throughout your section. We do not receive you as strangers, although you come from the other side of the line, because we consider that there is really no difference between the two peoples. I suppose you have a great many important questions to discuss, and therefore it is not my intention to occupy your time by any speech. I will only say that you are heartily welcome to our city, and if any of you gentlemen should happen to get into any little trouble during your stay here, I hope you will feel at liberty to call upon the Mayor. [Laughter.] I hope that your deliberations will be successful, and that those connected with our water department may get some good ideas from you which will tend to improve our water supply. [Applause.]

RESPONSE BY PRESIDENT WALKER.

PRESIDENT WALKER. I wish to thank you, Mr. Mayor, in behalf of the Association, for the welcome which you have extended to us, and to assure you that we appreciate it. It has been in the air for a number of years that we were coming to Montreal, and now that we are here we think we are going to have a good time, and we trust that you will think more of us when we go away than you did when we came. [Applause.]

AMENDMENT TO THE CONSTITUTION.

MR. CHARLES W. SHERMAN. A circular was sent out with the notice of this meeting calling attention to a proposed amendment to the constitution, and giving the reasons therefor. The amendment proposed is as follows:

Strike out from Section 2 the following:

“Which shall include a subscription to the Journal of the New England Water Works Association.”

Add a new section as follows:

“SECTION 4. — Three dollars of the dues of each member or associate, or such portion thereof as may be required, shall annually be applied to payment of a subscription to the Journal of the New England Water Works Association.”

The reason for this, as explained in the circular, is to satisfy the postal authorities, and at the same time save a great deal of clerical work. I move the adoption of this amendment.

Adopted.

ENGINEERS' CLUB OF MONTREAL.

Secretary Kent read the following communication, extending to the members the privileges of the Engineers' Club of Montreal.

At the request of Mr. T. W. Lesage the chairman and members of the committee of the Engineers' Club have the honor to extend to Mr. Willard Kent and members of the New England Water Works Association the privilege of the club-house for two weeks.

C. DE B. LEPROHON, *Secretary*.

On motion of Mr. Sherman, a vote of thanks was tendered to the Engineers' Club of Montreal for their invitation.

THE ST. LOUIS EXPOSITION.

Secretary Kent read the following communication from the committee of the American Society of Civil Engineers on the Universal Exposition to be held in St. Louis in 1904.

ST. LOUIS, MO., U. S. A., August 24, 1903.

TO THE NEW ENGLAND WATER WORKS ASSOCIATION,
BOSTON, MASS.:

The American Society of Civil Engineers has appointed the above-named Committee to represent it at the Universal Exposition to be held at St. Louis in 1904, to commemorate the Louisiana Purchase.

It is the purpose of this committee to collect and present an exhibit of plans, photographs, models, and descriptions of American engineering works, principally work designed by members of the American Society, which it is believed will be of great interest both to laymen and engineers. It is intended also to make the headquarters of the society, which will be in the Liberal Arts Building, a center of information as to other exhibits in the exposition which may be of engineering interest. There will also be a register which will help one to find and meet his friends, and it is hoped that the headquarters may serve as a rallying point and rendezvous for all visiting engineers.

The members of the New England Water Works Association are cordially invited to avail themselves of the conveniences to be provided by our society during their visit to St. Louis and the exposition, and it is hoped that a large proportion of them will be able to do so.

By order of the Committee,
H. J. PFEIFER, *Secretary*.

On motion of Mr. Fels, it was voted to extend the thanks of the Association to the American Society of Civil Engineers for their communication and to accept their invitation.

NEW MEMBERS ELECTED.

The Secretary read the following names of applicants for membership, all of whom were duly recommended by the Executive Committee.

For Resident Member.

J. J. Desmond, Lawrence, Mass., President Water Board; C. Dwight Sharpe, Putnam, Conn., Superintendent Putnam Water Works; George S. Brown, Danielson, Conn., Superintendent; Tyler H. Bird, Belfast, Me., Engineer, Superintendent and Collector, Belfast Water Company; Bernon E. Helme, Kingston, R. I., Managing owner water supply for village of Kingston; Phil S. Smith, Montpelier, Vt., Superintendent Montpelier Water Department; Charles H. Johnson, Exeter, N. H.; Joseph M. Birmingham, Hartford, Conn., President Board of Water Commissioners; Fred D. Berry, Hartford, Conn., Secretary Board of Water Commissioners; Jesse M. Shaw, Hingham, Mass., inspector and collector for Hingham Water Co.; T. Howard Barnes, C. E., Medford, Mass.; Harvey D. Eaton, Waterville, Me.; A. M. French, Holyoke, Mass., Water Commissioner.

For Non-Resident Member.

H. R. C. Blagden, Alexandria, Egypt, Chief Engineer Alexandria Water Works; S. A. Stearns, Granite, Ill., Superintendent Water Works of Granite City, Madison, and Venice; W. H. Humphreys, York, England, Manager and Chief Engineer of York Water Works; A. E. Woodward, Wolverhampton, England, Chief Engineer Wolverhampton Water Works; Joseph D. Pointer, Palatka, Fla.; George Janin, Montreal, Canada, Superintendent Montreal Water Works; Thomas W. Lesage, Montreal, Canada, Assistant Superintendent Montreal Water Works; W. E. Lautz, Pekin, Ill., Secretary Pekin Water Works Co.

For Associate.

G. Schumacher, Second Vice-President New York Central Foundry Co., New York, manufacturers universal cast-iron water pipe; William M. Rea, Somerville, Mass., salesman, A. W. Chester-ton Co.; Fred C. Gifford, Waltham, Mass.

On motion of Mr. Fuller the Secretary was instructed to cast one vote in favor of the applicants, which he did, and they were declared elected.

On motion of Mr. Sherman the President was requested to appoint a committee of five to nominate candidates for officers for the next year, and he subsequently named the following as the committee: Frank E. Merrill, F. W. Gow, A. E. Martin. T. G. Hazard, Jr., W. E. Hawks.

The afternoon session was occupied by a consideration of matters pertaining to the Montreal water supply. Mr. George Janin, superintendent of the Montreal Water Works, presented a paper giving a "History and Description of the Montreal Water Works." Following the reading of the paper, Mr. Hammond, Mr. Fred Brooks, Mr. Metcalf, Mr. Frank L. Fuller, Mr. Allen, Mr. Sherman, Mr. F. W. Dean, and others, asked questions which elicited from Mr. Janin and from Mr. Lesage, the assistant superintendent of the Montreal works, an elaboration of certain matters suggested by the paper.

Mr. T. W. Lesage followed with a paper entitled "Service Boxes of the Montreal Works."

In the evening, Mr. Frank L. Fuller, C.E., Boston, gave a description, illustrated by stereopticon views, of the work of

covering the Natick reservoir with a concrete roof. Mr. Leonard Metcalf opened the discussion which followed the reading of the paper, reviewing the recent developments in the use of the arch and modifications in the distribution of masonry in roofs. Mr. William B. Fuller spoke on the strength of the concrete groined arch, and Mr. F. W. Dean also participated in the discussion.

Mr. Henry Goldmark of the Canadian Pacific Railroad extended to the members of the Association an invitation to visit the extensive new locomotive and car shops of that road.

THURSDAY, SEPTEMBER 10.

At the morning session on Thursday, Mr. William R. Hill, chief engineer of the Croton Aqueduct Commission, read a paper prepared by Mr. John Venner, chief inspector, Bureau of Water, Syracuse, N. Y., on "Municipal Use and Waste of Water." The paper was discussed by Messrs. Harvey D. Eaton, Leonard Metcalf, Frank L. Fuller, F. W. Dean, and Kenneth Allen.

Mr. Charles W. Sherman presented a paper submitted in print by Mr. Frank C. Kimball, superintendent Knoxville Water Company, Knoxville, Tenn., entitled, "Some Six-Inch Meter Tests and How They Were Made." Mr. F. H. Crandall, who witnessed the tests as a member of the Committee on Private Fire Protection, gave his impressions from what he saw at Knoxville. On motion of Mr. Sherman it was voted to extend the privileges of the floor to any associates present representing meter companies, and in response to an invitation Mr. J. A. Tilden, who was present at Knoxville when the tests were made, spoke from the point of view of the meter manufacturers.

The next business was the consideration of the report of the Committee on Apportionment of Charges for Private Fire Protection and the Means of Controlling the Supply Thereto, which was presented by Mr. F. H. Crandall.

MR. CRANDALL. Your committee have conducted considerable correspondence and have had some meetings, and, as you all know, I was present at Knoxville and had opportunity to discuss the matter with Mr. Kimball, who is Mr. Wheeler's right-hand man, and I regard what Mr. Kimball said as practically what Mr. Wheeler said. Mr. Thomas of the committee and I are now

prepared to sign a report, but Mr. Wheeler is detained, for the same reason that Mr. Kimball is, in Knoxville.

I think it is time that this Association should give an expression of its opinion on this subject. I do not think it is necessary to wait for the development of different meters which are now on the market. An opinion can be expressed, and we have a report which we would like to make, and if you wish I will read it now. As I said a few minutes ago, there are devices which we hope may prove more satisfactory all around for the purpose of measuring water used for fire purposes than those at present on the market. There is one at present at the water-works station in Burlington, which will be tested in a short time by the maker, and if the test turns out as he hopes it will, and as we all hope it will, he will no doubt be glad to have later tests made by a committee of this Association. The report which we now have to make is as follows:

REPORT OF COMMITTEE ON

APPORTIONMENT OF CHARGES FOR PRIVATE FIRE PROTECTION AND THE MEANS OF CONTROLLING THE SUPPLY THERETO.

Mr. President and Gentlemen of the New England Water Works Association,—Your Committee on Apportionment of Charges for Private Fire Protection and the Means of Controlling the Supply Thereto would respectfully report their findings, as follows:

A large part of the expense of furnishing private fire protection is on account of the cost of mains, reservoirs, conduits, pumping machinery, and other requirements of the service, in no wise dependent upon the amount of water used, and varying for different services approximately in proportion to the capacity designed to furnish the area protected, or the size of the service.

The cost of furnishing private fire service has also been found, owing to legitimate use and waste, always present, to a greater or less degree, to vary with the quantity of water used, in consequence of which the price, to some extent, should vary with the quantity used. The only way to accomplish this, and secure a reasonable control of private fire services, is by means of meter measurement, and a charge for such service, in the determination of which the extra cost of increased capacity of system required and value to the user should not be overlooked.

Except for the fact that, under certain conditions, the water company or department is liable not to receive sufficient compensation, on account of the inability of the meter to register correctly small streams, there are several meters suitable for this use, and with an increased demand for accurate measuring devices suitable for such purposes there are liable to be several more.

Set in a by-pass around a gate, accessible to any one to open, in case of fire, and which it shall be the duty of the water department to see opened, under such circumstances, meters, now on the market, can meet with no reasonable objection except from the water departments, and will probably meet but little from that source.

On every fire service, beside a gate for the exclusive use of the water department, which should be located as near the main as possible, there should be a cut-off back of all fixtures, so located as under any probable combination of circumstances to be conveniently accessible for the use of the premises.

No private fire line should be allowed larger than six inches in diameter, and this size only when, in the opinion of the superintendent or manager of the water department, such size is necessary on account of the size and situation of the property requiring the private fire line, provided, however, that no private fire line of any size should be permitted that will, when all available protection from such line is being utilized, reduce the normal pressure in the supplying main more than one-third.

The furnishing of private fire protection free, while charging a fixed rate for a smaller service, whether water be used from same or not, is creating an arbitrary distinction in favor of the one and against the other taxpayer, which cannot be justified as classification, in that it denies the essential impartial treatment guaranteed by the law to all citizens.

It matters not that the private fire-protected plant of a wealthy corporation is an advantage to the community, Inasmuch as it is an advantage to the corporation served and an expense to the water works, it should, by all the principles of common law and common honesty, bear its fair share of the expense incident to the service.

All of which is respectfully submitted,

F. H. CRANDALL,

R. J. THOMAS.

MR. J. W. GOODELL. For the purpose of bringing the matter before the Association, that a vote may be had upon it, I move that the report of the committee be accepted and adopted so far as made and the committee continued. I think it will be for the interests of the Association to continue the committee, so that it may obtain further material to be submitted to us at some later date. Adopted.

Mr. F. H. Pitcher, chief engineer of the Montreal Water & Power Co., Montreal, Canada, then submitted a paper entitled, "Pumping by Electricity."

ELECTION OF MEMBERS.

W. C. Leitch, Superintendent Montreal Water & Power Co., and F. K. Bixbie, Superintendent Water Works, Lindsay, Ontario, were elected non-resident members.

At the afternoon session, Mr. M. F. Collins, Superintendent of Water Works, Lawrence, Mass., gave a description, illustrated by stereopticon views, of the filter plant at Lawrence; and the Hon. John O. Hall of Quincy, Mass., read a paper entitled, "The Reciprocal Obligation of the Management of a Water Supply and the Community." The President and Mr. F. H. Crandall spoke upon matters suggested by the paper.

At the opening of the evening session, Mr. Henry F. Jenks, for the Committee on Exhibits, reported that the exhibitors had been as follows:

1. Pittsburg Meter Co., Pittsburg, Ga., Keystone Meters.
2. Ross Valve Co., Troy, N. Y., Reducing Valves, Water Engines and Filters.
3. Hersey Mfg. Co., South Boston, Mass., Water Meters and Water Works Appliances.
4. A. W. Chesterton & Co., Boston, Mass., Steam Packings and Engineers' Supplies.
5. Thomson Meter Co., Brooklyn, N. Y., Samples of Lambert Water Meters and also the Lambert Typewriter.
6. Ashton Valve Co., Boston, Mass., Safety Valves, Pressure Gages, Water Gages, and Steam Whistles.
7. Lamb & Ritchie, Cambridgeport, Mass., Tin-Lined and Lead-Lined Pipe.
8. Union Water Meter Co., Worcester, Mass., Water Meters.
9. H. Mueller Mfg. Co., Decatur, Ill., Water Main Tapping Machine and Water Works Appliances.
10. Lead-Lined Iron Pipe Co., Wakefield, Mass., Lead and Tin-Lined Pipe and Fittings.
11. Neptune Meter Co., Long Island City, N. Y., Trident and Crescent Meters.
12. Central Foundry Co., New York City, New Water Pipe; Joints Made without Packing.
13. Greenwood & Daggett Co., Boston, Mass., Steam Packing.
14. Henry R. Worthington, Meters.

ELECTION OF MEMBERS.

Mr. James Laurin, Civil Engineer, Montreal, was elected a non-resident member.

Mr. Leonard Metcalf of Boston gave a very interesting descrip-

tion, illustrated by lantern slides, of a trip across Porto Rico. Frederick Brooks, C.E., of Boston, spoke on "The Folly of Reckoning by Gallons which Differ Widely in Canada and the United States, while Both Countries Have Identical Liters and Cubic Meters."

The report of the Committee on Uniform Statistics being called for, Mr. Joseph E. Beals, chairman of the committee, said that it had none to make.

MR. LEONARD METCALF. It seems to me that the work of this committee is not quite complete, and I would move that it be continued. This question of uniform statistics is coming up in various ways; I might refer particularly to a general system of municipal accounting, and I think it might be of advantage to the Association to continue the committee in existence so it may recommend such action as would seem to be wise for the Association to take in any such direction.

MR. KENT. I think it was the understanding when the committee was appointed that it should be continued indefinitely, or at least for a long time. Isn't that so, Mr. Sherman?

MR. CHARLES W. SHERMAN. At the time we were continued last year the committee had reported the changes that we thought desirable in the standard form of summarizing statistics, and suggested that a form for summarizing purification statistics ought to be prepared, but that we had not at that time been able to prepare such a summary, although we had done some work towards it, and we asked to be continued with authority to try the form that we should draw up. The preparation of such a temporary or experimental form of statistics of purification works was left to a sub-committee, consisting of Mr. Baker and myself. Neither of us has done anything on the matter. We still have some hopes that such a schedule may be prepared, although I confess that at the present moment the hope is not so sanguine as it formerly was. There is, however, a possibility, as Mr. Metcalf has suggested, that in these days of the consideration of uniform municipal accounting and other matters of that sort by various organizations, not merely water-works organizations, but others having municipal matters in consideration, some questions may come up where consideration by committees of different societies would be desirable, and consequently there might be something

gained, outside of the possible formulation of the schedule of purification statistics, by having the committee continued. At any rate, we cannot do any less than we have done the past year, and certainly no harm can be done.

Mr. Metcalf's motion to continue the committee was adopted, and the convention then adjourned.

NOVEMBER MEETING.

HOTEL BRUNSWICK,

BOSTON, November 11, 1903.

President Charles K. Walker in the chair.

The following members and guests were present:

MEMBERS.

S. A. Agnew, C. H. Baldwin, L. M. Bancroft, T. H. Barnes, J. E. Beals, George Bowers, Dexter Brackett, E. C. Brooks, Fred. Brooks, G. A. P. Bucknam, L. Z. Carpenter, George Cassell, G. F. Chace, J. C. Chase, F. C. Coffin, R. C. P. Coggeshall, M. F. Collins, W. R. Conard, J. W. Crawford, G. E. Crowell, F. W. Dean, A. O. Doane, G. E. Evans, B. R. Felton, C. R. Felton, J. N. Ferguson, J. A. Fitch, W. E. Foss, A. D. Fuller, F. L. Fuller, W. B. Fuller, H. F. Gibbs, Albert S. Glover, J. O. Hall, J. D. Hardy, L. M. Hastings, V. C. Hastings, T. G. Hazard, Jr., D. A. Heffernan, H. G. Holden, W. E. Johnson, E. W. Kent, Willard Kent, G. A. King, A. A. Knudson, C. F. Knowlton, E. S. Larned, F. A. McInnes, H. V. Macksey, W. E. Maybury, F. E. Merrill, Leonard Metcalf, F. L. Northrop, W. H. Richards, W. W. Robertson, E. M. Shedd, E. W. Shedd, J. H. Shedd, C. W. Sherman, H. O. Smith, G. H. Snell, G. A. Stacy, G. T. Staples, J. T. Stevens, J. J. Sullivan, C. N. Taylor, R. J. Thomas, H. L. Thomas, W. H. Thomas, J. L. Tighe, G. W. Travis, W. H. Vaughn, C. K. Walker, R. S. Weston, J. C. Whitney, W. P. Whittemore, G. E. Wilde, F. I. Winslow, G. E. Winslow. — 79.

ASSOCIATES.

Builders' Iron Foundry, by Frederick N. Connet; Chapman Valve Mfg. Co., by Edward F. Hughes; Charles A. Claffin & Co., by Charles A. Claffin; Coffin Valve Co., by H. L. Weston; Garlock Packing Co., by Edward N. Corning; Greenwood & Daggett Co., by W. H. Greenwood; Hersey Mfg. Co., by Albert S. Glover, James A. Tilden, and Walter A. Hersey; Henry F. Jenks; Lead-Lined Iron Pipe Co., by T. E. Dwyer; H. Mueller Mfg. Co., by W. L. Dickel; National Meter Co., by Charles H. Baldwin and J. G. Lufkin; Neptune Meter Co., by W. H. Van Winkle and H. H. Kinsey; Perrin, Seamans & Co., by James C. Campbell; Renssenlaer Mfg. Co., by Fred S. Bates; Sumner & Goodwin Co., by H. A. Gorham; Sweet & Doyle, by H. L. DeWolfe; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by F. L. Northrop; United States Cast Iron Pipe & Foundry Co., by Wm. B. Franklin. — 23.

GUESTS.

Randolph T. Ode, Providence Engineering Works, Providence, R. I.; Frank L. Weaver and R. J. Crowley, Water Commissioners, Lowell, Mass.; E. M. Peck, Engineer, Hartford, Conn.; R. E. Walsh, Water Registrar, Woburn, Mass.; Albert F. Hill, Superintendent Pawtuxet Valley Water Co., Phenix, R. I. — 6.

The following named were elected resident members:

William T. Barnes, Boston, Hydraulic and Sanitary Engineer; Ennan Miland Peck, West Hartford, Conn., Distribution Engineer of the Hartford Water Works; Albert F. Hill, Phenix, R. I., Superintendent of the Pawtuxet Valley Water Works Company.

Mr. J. Herbert Shedd then presented a paper entitled, "Requisite Amount of Water for Public Supply." A long discussion followed, which was participated in by Messrs. Holden, Winslow, Hastings, Chace, Taylor, Albert F. Hill, Larned, Richards, Coggeshall, Robertson, Robert J. Thomas, Edwin C. Brooks, Connet, Brackett, Foster, and Dean.

Mr. Francis W. Dean presented a paper entitled "Pumping Engines."

Adjourned.

EXECUTIVE COMMITTEE.

The Executive Committee met at headquarters, Tremont Temple, at 12 M., November 11, 1903, Vice-President Brooks in the chair, and present, also, Messrs. Willard Kent, E. W. Kent, L. M. Bancroft, G. A. Stacy and C. W. Sherman. Three applications for membership were considered, and it was voted to recommend the applicants to the Association for election.

Adjourned.

WILLARD KENT, *Secretary*.

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Association.

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176 TO 184 HIGH STREET

BOSTON, MASS.

INDEX.

- Allen, Kenneth.** A wood-stave conduit for the water supply of Atlantic City. 375-387, additional notes (C. J. Myers) 387-390, disc 391-395.
- Atkinson, Edward.** Bog fuel. 414-424, disc 424-426.
- Atlantic City, N. J. ALLEN, KENNETH.** Wood-stave conduit. 375-387, additional notes 387-390, disc 391-395.
- Assessment for water to metropolitan water district. BRACKETT, DEXTER.** 147-156.
- Baker, M. N.** Local boards of health and epidemics. 456-460.
- Bancroft, Lewis M.** Treasurer's annual report. 81-86.
- Batchelder, George E.** Portrait. 324.
- Betton, James M.** Extracts from a "Report relative to supplying the City of New York with pure and wholesome water, November, 1833." 254-263.
- Bog fuel. ATKINSON, EDWARD.** 414-424, disc 424-426.
- Boiler. WALKER, C. K.** For thawing frozen pipes, etc. 217.
- Book review. THRESH, J. C.** The examination of waters and water supplies. 490-491.
- Brackett, Dexter.** Portrait. 312.
Report on the measurement, consumption, and waste of water supplied to the metropolitan water district. 107-160.
- Broatch, John C.** Died 2 April 04. Obituary 245.
- Brooks, Edwin C., Pres N E W W A.** Portrait. *Frontispiece.*
- Burke, James E.** Died 23 Feb 04. Obituary 334.
- Cast iron pipe.**
CAVALLIER, C. Life of cast iron pipe. 218-221.
SHEDD, J. H. Providence pattern of bells and spigots. 3.
- Cavallier, C.** The life of cast iron pipe. 218-221.
- Chace, George F.** Portrait. 322.
- Clark, Dennis Woodruff.** Died 18 April 04. Obituary 486.
- Coffin, Freeman C.** Meter rates. 55-57.
- Coggeshall, Robert C. P.** Up to 1895 — Some reminiscences (of N E W W A). 300-330.
- Concrete.**
HAWLEY, W. C. Method and cost of making waterproof by Sylvester process (soap and alum). 176-181.
SMITH, J. W. Little Falls, N. J., filter plant. 181, 182.

- Composition metal.** SHEDD, J. H. For service cocks. 24.
- Consumption of water.**
 BRACKETT, D. In metropolitan water district. 107-160
 SHEDD, J. H. Providence, R. I. 6-13.
- Contract and specifications for furnishing cast iron water pipes and special castings,** New Bedford Water Works. 264-276.
- Cook, Byron I.** Portrait. 328.
- Cowan, Edward H.** Detection and prevention of water waste at Marion, Ohio. 185-192.
- Crandall, Frank H.** Portrait. 328.
- Curb boxes.** See Service boxes.
- Curtis, George D.** Died 26 June 04. Obituary 334.
- Dam.**
 RICHARDS, W. H. New London, Conn. 69-70.
 SICKMAN, A. F. Holyoke, Mass. 340-346.
- Darling, Edwin.** Portrait. 308.
- Deacon meter.** BRACKETT, D. 140-147.
- Dean, Francis W.** Improvements in economy of pumping engines. 25-31.
- Drown, Dr. Thomas M.** Died 16 Nov 04. Obituary 489.
- Economy in pumping engines.** DEAN, F. W. 25-31.
- Electric thawing of service pipes.** MCINNIS, F. A. Boston. 214-216.
- Ellis, George A.** Died 27 Dec 03. Obituary 105.
- Epidemics.**
 SMITH, E. G. Baraboo, Wis. 453-456.
 SOPER, G. A. Ithaca, N. Y. 431-449, disc 449-461.
- Evaporation.** HASTINGS, L. M. 41-44.
- Fire protection, private.**
 Committee of N E W W A. Progress report 198-203, disc 203-213.
 Report (Thomas, R. J.) 427-429, disc 429, 430.
 PURDY, J. H. For factories: how its value should be determined and who should pay for it. 193-197.
- FitzGerald, Desmond.** Portrait. 328.
 Address and verses. 480-482.
- France.** CAVALIER, C. Old water pipe systems. 218-221.
- Freezing of house meters.** Disc 65, 66.
- French, Arthur M.** The Holyoke water supply. 396-413.
- Frozen service boxes, pipes, etc.** Disc 58-64.
- Fteley, Alphonse.** Died 11 June 03. Obituary 104.
- Fuel, Bog.** ATKINSON, EDWARD. 414-424, disc 424-426.
- Gerhard, William Paul.** The driven wells at the Mount Washington Hotel—a correction. 247-252.

- Harris, Dwight A.** Died 16 June 04. Obituary 335.
- Haskell, John C.** Portrait. 328.
- Hastings, Lewis M.** Rainfall and run-off from catchment areas in New England. 32-53, disc 53, 54.
- Hawley, William C.** Some notes on waterproofing the concrete lining of reservoirs (Sylvester process, — soap and alum). 176-181, disc 181-184.
- Hering, Rudolph.** Additional water supply for New York City. 360-374.
- Holden, Horace G.** Portrait. 320.
- Holyoke, Mass.** Twenty-third annual convention at. 462-478.
- FRENCH, A. M.** The Holyoke water supply. 396-413.
- SICKMAN, ALBERT F.** The water power at Holyoke. 337-351.
- Ithaca, N. Y.** **SOPER, G. A.** The epidemic of typhoid fever at Ithaca. 431-449, disc 449-461.
- Jenks, Henry F.** Died 11 Sept 04. Obituary 487.
- Joints of pipes.**
- BROOKS, EDWIN C.** Old Scotch pipe with 7-inch bell, Cambridge. 16.
- SHEDD, J. H.** Providence pattern, 3. Amount of lead required, 15.
- Kent, Willard.** Portrait. 328.
- Secretary's annual report. 79-81.
- Lime, use of, in thawing frozen ground.** 60.
- McInnes, Frank A.** Thawing frozen service pipes by electricity. (Boston.) 214-216.
- Marion, Ohio.** **COWAN, E. H.** The detection and prevention of water waste. 185-192.
- Meter box.** **COWAN, E. H.** 187, 188.
- Meters.**
- BRACKETT, D.** In metropolitan water district. 143-147.
- Discussion. Freezing of house meters. 65-66.
- SHEDD, J. H.** Effect of, on consumption of water in Providence. 6-13.
- Meter rates.**
- COFFIN, F. C.** 55-57.
- Discussion. 222-242.
- Metropolitan water district.** **BRACKETT, D.** Measurement, consumption, and waste of water. 107-160.
- Miller, Col. Alexander M.** Died 14 Sept 04. Obituary 488.
- Mosquitoes.** **UNDERWOOD, W. L.** Suggestions for their extermination. 161-171, disc 171-175.
- Mount Washington Hotel.** **GERHARD, W. P.** Driven wells. 247-252.
- Myers, C. J.** Some additional notes on the wood-stave conduit at Atlantic City, N. J. 387-390.

New Bedford, Mass. Form of contract for furnishing cast iron pipes, etc.
264-276.

New England Water Works Association. Addresses.

CHAPIN, A. B., Mayor of Holyoke. 464.

FITZGERALD, D. 480.

MCLEAN, HUGH. 476.

SHERRERD, M. R. 482.

SULLIVAN, J. J. 466.

WALKER, C. K. President's annual address 13 Jan 04. 78, 79.

WHITCOMB, M. H. 465

NEW WWA Committees.

Executive committee. Proceedings.

9 Dec 03. 102.

13 Jan 04. 102.

10 Feb 04. 102.

9 Mar 04. 245.

19 May 04. 332.

22 June 04. 333.

19 Aug 04. 484.

14 Sept 04. 484.

15 Sept 04. 484.

9 Nov 04. 485.

Uniform hydrant and hose threads. Appointed. 469, 470.

Private fire protection. Progress report. 198-203, disc 203-213.

Informal report (R. J. Thomas). 427-429, disc 429, 430.

Rates for metered water. Appointed. 91.

NEW WWA Exhibits. At twenty-third annual convention. 473.

NEW WWA History. COGGESHALL, R. C. P. Up to 1895 — Some reminiscences. 300-330.

NEW WWA Meetings.

1903, Dec 9. Proceedings. 73-76.

1904, Jan 13. Annual meeting. Proceedings. 76-93.

Feb 10. Proceedings. 94-102.

Mar 9. Proceedings. 243, 244.

June 22. Excursion. 331, 332.

Sept 14, 15, 16. Twenty-third annual convention. Proceedings.
462-478.

Nov 9. Proceedings. 478-483.

NEW WWA Members.

Honorary, Election of. 471, 472.

Obituary.

Broatch, John C. Died 2 Apr 04. 245.

Burke, James E. Died 23 Feb 04. 334.

Clark, D. W. Died 18 April 04. 486.

Curtis, George D. Died 26 June 04. 334.

- Drown, Thomas M. Died 16 Nov 04. 489.
 Ellis, George A. Died 27 Dec 03. 105.
 Fteley, Alphonse. Died 11 June 03. 104.
 Harris, Dwight A. Died 16 June 04. 335.
 Jenks, Henry F. Died 11 Sept 04. 487.
 Miller, Alexander M. Died 14 Sept 04. 488.
 Shirreffs, Reuben. Died 31 Aug 04. 487.
 Sweet, Kilburn S. Died 15 July 04. 486.
 Wescott, George P. Died 22 Oct 04. 488.

N E W W A Officers.

- Editor, annual report of. 1903. 87-89.
 Election. 90.
 Secretary, annual report of, 1903. 79-81.
 Treasurer, annual report of, 1903. 81-86.

N E W W A Portraits.

- Batchelder, George E. Facing 324.
 Brackett, Dexter. Facing 312.
 Brooks, Edwin C. *Frontispiece*.
 Chace, George F. Facing 322.
 Cook, Byron I. Facing 328.
 Crandall, Frank H. Facing 328.
 Darling, Edwin. Facing 308.
 FitzGerald, Desmond. Facing 328.
 Haskell, John C. Facing 328.
 Holden, Horace G. Facing 320.
 Kent, Willard. Facing 328.
 Nevons, Hiram. Facing 310.
 Stacy, George A. Facing 326.

New London, Conn. RICHARDS, W. H. Notes on the construction of a storage reservoir. 67-72.

New York, N. Y.

- BETTON, J. M. Extracts from report on water supply, 1833. 254-263.
 HERING, RUDOLPH. Additional water supply. 360-374.

Nevons, Hiram. Portrait. 310.

Peat. *See* Fuel.

Pipe, cast iron. *See* Cast iron pipe.

Pipe, service. *See* Service pipe.

Pumps, slip of. 22-24.

Pumping engines. DEAN, F. W. Improvements in economy of. 25-31.

Purdy, J. H. Fire protection for factories. How its value shall be determined and who shall pay for it. 193-197.

Quantity of water required. SHEDD, J. H. For public supply. 1-14, disc 14-24.

- Rainfall.** HASTINGS, L. M. And run-off from catchment areas in New England. 32-53, disc 53, 54.
- Rates.** See Water rates.
- Reminiscences (of N E W W A).** COGGESHALL, R. C. P. 300-330.
- Revenue.** TIGHE, J. L. Municipal water supply revenue. 352-357, disc 358, 359.
- Richards, Walter H.** Notes on the construction of a storage reservoir. (New London, Conn.) 67-72.
- Service pipes.** SHEDD, J. H. Capacity. 5.
- Shedd, J. Herbert.** Requisite amount of water for a public supply. 1-14, disc 14-24.
- Sherman, Charles W.**
Editor's annual report. (1903.) 87-89.
Water works statistics for 1903. 277-299.
- Shirreffs, Reuben.** Died 31 Aug 04. Obituary 487.
- Sickman, Albert F.** The water power at Holyoke. 337-351.
- Smith E. G.** Typhoid fever epidemics. 453-456.
- Soper, George A.** The epidemic of typhoid fever at Ithaca, N. Y. 431-449, disc 449-461.
- Stacy, George A.** Portrait. 326.
- Statistics of water works for 1903.** 277-299.
- Stealing water.**
Lowell, Mass. 19, 20.
Providence, R. I. 13, 14.
- Storage reservoir.** RICHARDS, W. H. Notes on construction. 67-72.
- Streams, flow of.** HASTINGS, L. M. 32-54.
- Superheated steam.** DEAN, F. W. In pumping engines. 28-31.
- Sweet, Kilburn S.** Died 15 July 04. Obituary 486.
- Taxation.** TIGHE, J. L. Of municipal water works. (Holyoke.) 352-357, disc 358, 359.
- Thawing.**
Discussion. Frozen service boxes, pipes, etc. 58-64.
McINNES. Frozen service pipes, by electricity. (Boston.) 214-216.
WALKER, C. K. Portable boiler for. (Manchester, N. H.) 217.
- Thomas, Robert J.** Report for committee on private fire protection. 427-429, disc 429, 430.
- Tighe, James L.** Municipal water supply revenue. 352-357, disc 358, 359.
- Tilden automatic valve for private fire services, etc.** 198-203.
- Typhoid fever.** SOPER, G. A. Epidemic at Ithaca, N. Y. 431-449, disc 449-461.
- Underwood, William Lyman.** Mosquitoes and suggestions for their extermination. 161-171, disc 171-175.

Valve, Tilden automatic. 108-203.

Venturi meter, used in metropolitan water district. 110-116.

Walker, Charles K.

Address, President's annual. 78, 79,

Portable boiler for thawing frozen pipes. 217.

Waste of water.

In metropolitan water district. 107-160.

In New York City. 364-366.

In public buildings.

Cambridge, Mass. 20.

Metropolitan water district. 127-147.

New Bedford, Mass. 21.

Prevention of. 1-14.

COWAN, E. H. Detection and prevention, Marion, Ohio. 185-192.

Water power. SICKMAN, A. F. Holyoke. 337-351.

Water-proofing. HAWLEY, W. C. Concrete lining of reservoirs. 176-181, disc 181-184.

Water rates.

COFFIN, F. C. Meter rates. 55-57.

Discussion. Meter rates. 222-242.

SHEDD, J. H. Providence, R. I. 6-13.

TIGHE, J. L. Revenue and taxation of water works. 352-357.

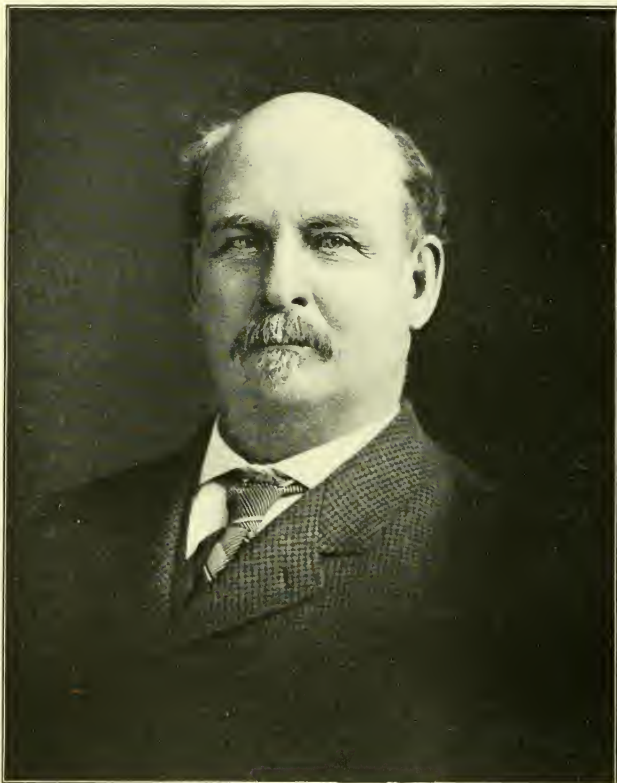
Water supply. FRENCH, A. M. Holyoke, Mass. 396-413.

Water works statistics for 1903. 277-299.

Wells, driven. GERHARD, W. P. At the Mt. Washington Hotel. 247-252.

Wescott, George P. Died 22 Oct 04. Obituary 488.

Wood-stave conduit. ALLEN, K. Atlantic City, N. J. 375-387, disc 387-395.



EDWIN C. BROOKS.

President of the New England Water Works Association,

1904

570

NEW ENGLAND WATER WORKS ASSOCIATION.

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No. 1.

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REQUISITE AMOUNT OF WATER FOR A PUBLIC SUPPLY.

BY J. HERBERT SHEDD, CONSULTING ENGINEER, PROVIDENCE, R. I.

[Read November 11, 1903.]

The useless waste of water is a serious loss and expense in nearly every community having a public water supply.

If any possible good could be accomplished by it some show of defence might be advanced for the practice, but it seems to be a loss and evil in every way. It has been suggested that the sewers are benefited by this flow of water, but the advantage, if any, in that respect is more than offset by the need of greater capacity in the sewer channels. A very small percentage of this waste if applied in flushing the sewers would be greatly more useful. An effort is usually made, in designing and building sewers, to keep out the ground water, but clearly the ground water would serve fully as good a purpose as a cleansing medium as the waste from the water works, and an additional advantage would come from its admission in the lowering of the water table about the foundations and the cellars of the buildings.

A liberal use of water ought to be provided in every family to insure cleanliness and every sanitary advantage, and an abundant flow everywhere for such purposes, and a liberal supply for all other legitimate objects, should be classed as use; but beyond this the waste is, I think, an unmixed evil.

Of the volume of water ordinarily supplied to a distribution system, much the larger portion, often reaching two-thirds or more

of the amount supplied, is uselessly wasted, and only a smaller portion is applied to any beneficial purpose. Such a condition ought not to exist, and it would seem to be the duty of every person having a position of authority in relation to a public supply to endeavor to limit the expenditure to that which will secure useful results, and to check or stop the reckless waste of money which now prevails.

The essential conditions for limiting a supply of water to useful purposes may be stated as follows:

1. A tight distribution and service system.
2. A proper system of water rates, inducing the water takers to desire the use of meters and not be opponents of their use.
3. The measurement of all water drawn by takers and payment in proportion to volume. As an incident to this a determination of the supply required for various uses is desirable.
4. Watchfulness on the part of those in charge of the works to detect and remedy any abnormal conditions in the supply.

First. — Upon works already established, but little can be done to increase the tightness of the distribution and service systems except by repairs and renewals; but as very few systems are finished, the extensions may be made in a way to secure reasonably tight work. To this end the street mains should be made under proper specifications as to shapes and quality, and these should be enforced by proper and rigid inspection, at the foundry, by inspectors whose decisions cannot be warped in the interest of the pipe contractors. The shapes and dimensions of the bells and spigots are important elements in securing tight work. My experience leads me to the belief that as a rule the bells of water pipes are made too deep. In the city of Providence, where there are now about 340 miles of distribution pipes in service, and forming an extremely tight system, the bells are 2 inches deep for the 6-inch pipes and regularly increasing in depth to 4 inches for the 36-inch pipes (see Fig. 1). These straight pipes can be laid on sharper curves without affecting the tightness of the joint than would be possible with the deeper bells. These shallow bells have been in use on the system for about thirty-three years, and I believe no one having experience with them would be willing to use in their place the ordinary deeper bells. The specifications under which they are made require accurate work as to their form. In all

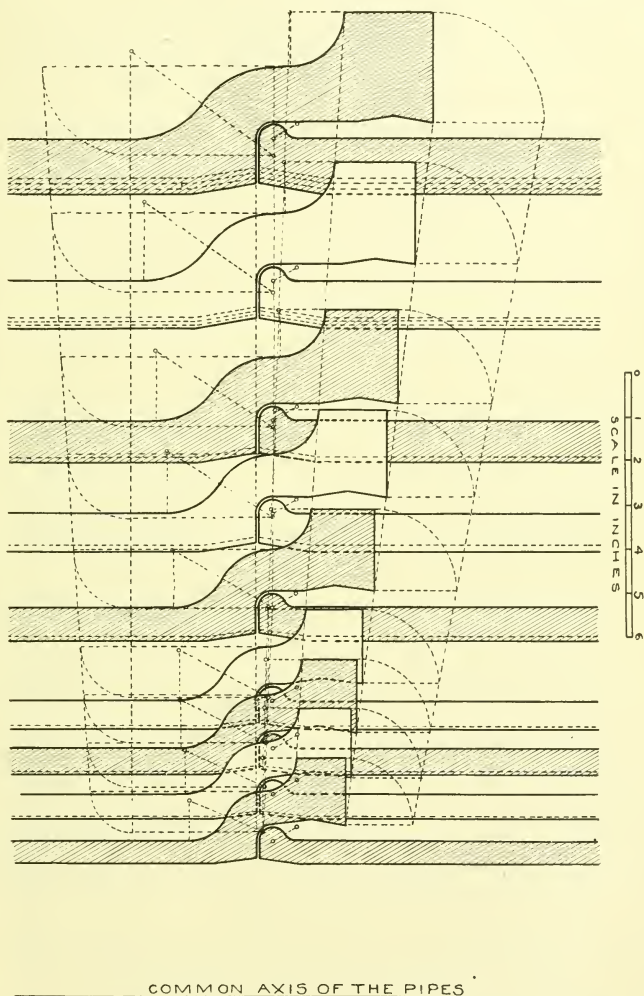


FIG. 1. PROVIDENCE PATTERN OF WATER-PIPE BELLS AND SPIGOTS.

respects the specifications and inspection have been very rigid, but the city of Providence can buy its water pipes at the lowest prices notwithstanding the requirements. The foundries seem to seek the city's orders, for the reason possibly that they know that while they will be held strictly to the contract they will receive fair treatment from experienced men, and a certain foreknowledge of that fact outweighs any extra care their operatives are put to, to turn out perfect pipe.

In addition to the inspection at the foundries there should be careful and faithful inspection of the pipes as they are received at the pipe yard, especially to discover any faint cracks which may have developed in transportation.

The proper widths and proper compacting of the gaskets and the lead in the joints is, of course, important.

The tightness of the service pipes in Providence is secured by requiring the best materials and the best workmanship. Before the mixture forming the bronze for making the taps and stops was determined upon, a large number of experiments was made upon various bronzes, and a mixture securing toughness, strength, tightness, and ease of working in the shops, so far as these could be combined, was selected. The work upon the tap, service pipe, and stop, forming a service, was done by the regular employees in the shop at the pipe yard of the department, and the tap was set in the street main, and the service pipe laid, by the department men.

Second. — The system of water rates should be based on the opportunity of each taker to waste water — that is, upon the number and character of the fixtures. This matter is discussed further under the third head. The size of service pipe should be based on the requirement for delivering useful water. A diagram giving the loss of head resulting from delivering certain quantities of water through the taps, service pipes, and stops of different sizes and for various lengths of pipe is a valuable aid in fixing the sizes of service pipes to be laid for takers. Such a diagram (Fig. 2) was made at the beginning of the delivery of water in Providence, and its value has been demonstrated continuously. Cases sometimes occur in which it is appropriate to insert a diaphragm in the tap having a hole of suitable size through it to deliver, without undue loss of head, all the water which can be made useful, but which would serve to throttle an excessive draft.

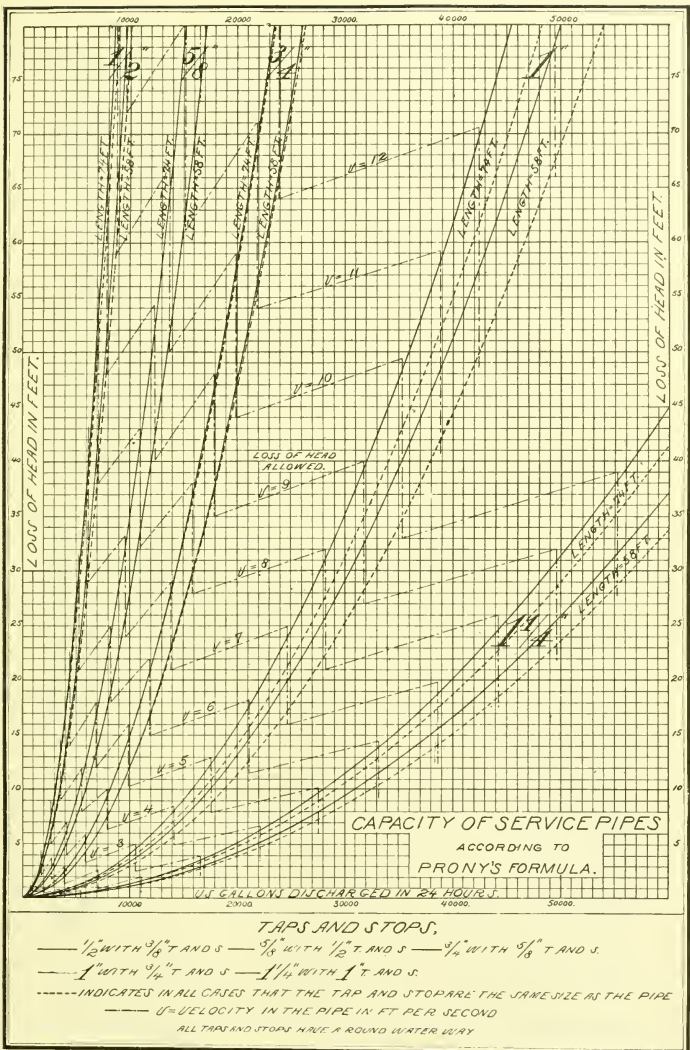


FIG. 2.

Third. — The measurement of the amount of water delivered to a taker forms the only just basis for the payment of a water rate. The advantage of a system of water supply for the general protection against fire is a proper cause for a public tax, and, generally, this should yield about half the revenue for a system of water works. Other public and general uses may also be provided for by a tax upon the whole community, but the private consumer should pay according to the quantity of water he uses, with a proper provision for a minimum rate.

Excellent means of measurement are now available both for large and for small amounts. The Venturi meter has been of great value in measuring large supplies, whether in gaging supplies to the whole of, or to portions of, a system of distribution. Other meters of various forms, suitable and not too expensive, are now available for ordinary takers. There is therefore no sufficient objection, because of cost or uncertainty, to basing a water rate on the volume of water supplied, especially as the cost of the supply is largely dependent on the volume.

It seems to be popularly assumed that waste cannot be prevented, because it is not in human nature to submit to the sort of control necessary to limit the supply to useful purposes. But human nature does submit when properly treated, for we have several examples in New England of a contented community feeling that it has an abundant and free supply of all the water it cares to take and yet its per capita supply is far below that furnished to other communities similarly situated and of similar character. Whether human nature will submit, may depend upon how it is approached.

The city of Providence in Rhode Island is one of these communities that submits to the limiting of waste, and if there is another people more imbued with the rights of soul liberty and individual freedom to do as one pleases with what is his own I have failed to find it. Possibly the community may not know that it is submitting.

The city is preeminently a manufacturing place, and has many large users of water. An examination of the experience of the Water Department of Providence would therefore seem to be useful. I will take this city as an example illustrating a method of satisfying the water takers, and as showing the amount of

water required for a public supply. It seems to be appropriate also that I should do so because of my familiarity with the conditions obtaining in it. I was the designing and constructing engineer while the works were building, occupying a period of about seven years, during about five of which water was supplied to takers numbering at completion over a hundred thousand people. And after an interval of about thirteen years I again came into the department as city engineer for another period of seven years, at the end of which time the water takers numbered about one hundred and sixty-five thousand. My advice was followed in the beginning in fixing a basis or scheme according to which the revenue to be claimed from takers should be ascertained and controlled and economy of supply secured.

As a basis for determining the amount to be paid for water by takers, when it was not to be measured by meter, the opportunity to waste water was considered to be of the greatest importance. More water being wasted than used, the means of *wasting* water should govern the rental. This led to a schedule based upon the fixtures connected with the water pipes. Naturally the well-to-do, under this schedule, would pay more than the poor in proportion to the amount of water actually used, but a very important point was gained in the inducement offered to those who had many fixtures, to put in and maintain at their own expense meters for measuring the water taken by them. The water takers thus became the advocates of meters, and nearly all the meters on the works, numbering now nearly twenty thousand, or nearly 85 per cent. of all the services, have been applied at the request of the water takers. Possibly one quarter of one per cent. are exceptions, but probably the exceptions are less even than this small number.

When the rates were fixed the price for measured water was the common one, at that time in New England, of three cents per hundred gallons, and it was thought that ten dollars per year would pay, at that rate, for all the water that would be legitimately used by an ordinary family. It was important for sanitary reasons that no person should be restricted in the liberal use of water, and therefore a minimum rate was fixed so that no temptation should exist to lessen the real use of water, but only to prevent waste. The minimum charge of ten dollars per year was

therefore fixed for all who took *measured* water. That this was a fair estimate was proved by experience. Fifteen years after the delivery of water began about one half of all the families supplied by meter were paying the minimum rate, which entitled them to 91.32 gallons of water per family per day or, upon the basis of five persons per family, to 18.26 gallons per capita. It was noticed for many years that a large portion of the families supplied by meter did not draw more than about five dollars' worth per year. It is to be remembered that the poorer people are excluded from this list. They were generally supplied by one faucet at six dollars per year. It was only those who were supplied with extra fixtures for their convenience who had an object in paying for and maintaining a meter, and they could have no selfish incentive to save the water within the value of ten dollars per year. They used all they wanted, but they did not waste the water.

In 1888, seventeen years after the introduction of water, an analysis was made of the accounts of water takers through meters to determine the relative numbers of those using water within the minimum rate and also those using water amounting to other annual sums. Of those who were paying the minimum rate, I have examined the accounts of 2 553 families to learn the amounts of water drawn by each, and I have found that —

	<i>Per annum.</i>	<i>Gals. per day per tap</i>	<i>Which at 5 persons per family</i>
167 families drew less than	1 500 cu. ft.	=30.742	= 6.15 gals. per capita
237 families drew the previous amount but less than	2 000 cu. ft.	=40.989	= 8.20 gals. per capita
361 families drew the previous amount but less than	2 500 cu. ft.	=51.236	=10.25 gals. per capita
445 families drew the previous amount but less than	3 000 cu. ft.	=61.484	=12.30 gals. per capita
446 families drew the previous amount but less than	3 500 cu. ft.	=71.731	=14.35 gals. per capita
462 families drew the previous amount but less than	4 000 cu. ft.	=81.978	=16.40 gals. per capita

	<i>Per annum.</i>	<i>Gals. per day per tap</i>	<i>Which at 5 persons per family</i>
435 families drew the previous amount but less than	4 457 cu. ft.	=91.324	=18.27 gals. per capita

Twenty-five hundred and fifty-three families of a good class are thus shown to be using only from six to eighteen gallons of water per capita per day, and the number of families using even the least amount is too great to be put one side as abnormal. Some of the families using the smaller quantities are known to me to be liberal in all their ways of living and not economical to the extent of stinting themselves in any comfort or convenience. I think it is probable that the reason why some families use more than others is largely because of outside uses, like watering lawns, use in stables, greenhouses, etc., and because there are more members in the families. The amount of ground around the dwellings of Providence is unusually large. To illustrate the effect of outside uses on the quantity of water drawn I will instance the bills for eight successive years of the use of water at my own house, where the variation was almost solely caused by use on my large lawn. There were six to seven persons in the family, water in set fixtures on four floors, in modern conveniences, and a stable supplied through the house meter. The meter rate during this period was $2\frac{1}{4}$ mills per cubic foot, or 3 cents per 100 gallons. The amounts of the bills were —

1st year	\$10.52	5th year	\$18.36
2d "	47.21	6th "	18.05
3d "	28.25	7th "	17.87
4th "	56.50	8th "	14.59

This represents a per capita use for one year of say 80 gallons, and I suppose it was all used and not wasted, but it could hardly be classed as domestic or family use.

For an illustration of the relative number of meters passing different quantities of water for all uses, I will instance the analysis in Providence, in 1888, to which I have previously alluded. The number of meter accounts was 7 074, which are set out below in eleven classes.

<i>Class.</i>	<i>Number of accounts.</i>	<i>Amount of revenue received.</i>
Minimum charge (\$10)	2 681	\$26 810.00
\$10 to \$15	1 542	19 028.64
15 to 20	887	15 343.82
20 to 30	861	20 725.10
30 to 40	393	13 610.25
40 to 50	176	7 856.98
50 to 100	294	19 598.41
100 to 300	161	23 486.83
300 to 500	36	11 766.39
500 to 1 000	30	14 766.53
1 000 and excess	13	12 577.89
	<hr/> 7 074	<hr/> \$185 570.84

At the time this analysis was made, a sliding scale of discount was in operation as follows:

10%	discount on excess over	\$50 to	\$100
20%	" " " "	100 "	300
30%	" " " "	300 "	500
40%	" " " "	500 "	1 000
50%	" " " "	1 000	

This was afterwards changed to a uniform rate of $1\frac{1}{2}$ mills per cubic foot, or 2 cents per 100 gallons, subject to a discount of 25 per cent. for amounts in excess of \$600 per year in value. The accounts were classified according to the *gross* charge, and the *revenue* is given after the discount has been deducted, which accounts for the apparent discrepancy in the statements under classification and those under revenue; for instance, the 13 accounts given as exceeding \$1 000 amounted in gross to \$20 085.80 and the sum of the discounts, at various stages, amounted to \$7 507.91, which deducted leaves \$12 577.89, the sum stated under revenue.

At the present time there are nearly twenty thousand meters in use, and of the rest of the services, say three thousand five hundred in number, all, probably, but about one per cent., are for supply to families using a single faucet, or two. The use of water from these services is satisfactory to the department, and it is believed from reports of the inspectors that no waste of consequence occurs.

Probably five sixths in number of all the services are used to supply families, and about half the services supply takers at the minimum meter rate or less, but there are very large takers on the system, and I believe that the proportion of the volume of water per capita used for other purposes than family use is greater

than in most of the other cities of the country. One taker, the railroad, draws about 450 000 gallons per day, a public institution draws about 250 000 gallons per day, and the electric light company draws about 200 000 gallons per day. There are fifty-two private takers who pay a water rate of more than a thousand dollars per year each. Of course these large takers run up the per capita use by the population very largely, and the influence of such takers must vary considerably between different cities. It must be instructive, however, to consider as a whole the experience of any large city which has succeeded in maintaining a moderate per capita use of water.

I give, in the table on the following page, some interesting facts in regard to the conditions, as a whole, in Providence, and will say that I believe an equally low per capita use might be secured in nearly every city of the country where such use is now exceeded, without permanently annoying its inhabitants and greatly to the advantage of such city in its tax rate or in its expense for maintaining water works, however its funds are raised for that purpose.

In the year 1892 the department noticed what was considered to be an unnecessary per capita use of water, and special inspectors were engaged to examine the supply through services, and the returns of the ordinary inspection were reviewed in the office to discover a reason for such use. About two years were occupied in the examination and in applying remedies. It was found that upon many of the unmetered services there was large waste, and the takers on such services were notified that under the provision in the published rates allowing special assessments to be made for peculiar circumstances they would be subjected to such special assessment, unless they chose to put on meters. A considerable number of such takers had meters set, and the rate of increase in the number of meters showed the influence of this move. The examination and the effort to check waste reached its culmination in 1894. In that year the average daily consumption of water was 9 904 434 gallons and the per capita supply was 65.24, which was larger than it had been before or has been since and undoubtedly more than was reasonable. The effect of the special effort to check waste was shown in the following year in two ways that were striking, when observed upon a profile illustrating the

conditions obtaining upon the work. *First:* The total average daily consumption of water dropped to 8 905 085 gallons and the per capita supply to 56.93 which was still fully up to the requirements for use. *Second:* The rate of increase in the revenue shot up in a marked way. The full effect of the effort to check waste was not, however, shown until 1897 when the total average daily

DISTRIBUTION, POPULATION AND PER CAPITA SUPPLY OF WATER
IN PROVIDENCE, R. I.

Year.	Miles of street mains.	Population supplied.	Miles of pipe per M. population.	Per capita supply of water. (Gallons.)	Percentage of services metered.
1877	143.9212	÷ 102 900	= 1.3983	24.21	41.86
1878	149.0662	÷ 104 800	= 1.4224	25.79	43.16
1879	151.3890	÷ 106 875	= 1.4184	29.10	44.91
1880	154.5663	÷ 109 400	= 1.4128	32.42	46.62 Mar., '80
1881	159.4044	÷ 112 200	= 1.4207	33.13	47.65 Nov., '80
1882	166.7196	÷ 115 100	= 1.4485	31.85	No record
1883	176.6755	÷ 118 000	= 1.4973	35.12	52.38
1884	183.8386	÷ 120 900	= 1.5206	33.77	53.70
1885	189.3045	÷ 123 800	= 1.5291	38.21	55.45
1886	194.2298	÷ 126 700	= 1.5330	38.06	56.84
1887	203.3894	÷ 129 700	= 1.5681	38.08	58.06
1888	210.3669	÷ 132 600	= 1.5865	41.61	59.32
1889	218.0101	÷ 135 700	= 1.6066	42.64	60.61
1890	226.4792	÷ 138 700	= 1.6329	48.61	62.45
1891	243.5319	÷ 141 800	= 1.7174	51.28	63.42
1892	257.7153	÷ 144 900	= 1.7786	55.61	65.48
1893	273.2654	÷ 148 000	= 1.8464	63.30	69.40
1894	284.7603	÷ 151 800	= 1.8759	65.24	72.46
1895	296.2754	÷ 156 400	= 1.8943	56.93	74.58
1896	303.1921	÷ 162 200	= 1.8693	56.14	76.50
1897	310.3458	÷ 168 200	= 1.8451	51.34	78.42
1898	314.8528	÷ 174 200	= 1.8078	52.52	80.04
1899	318.4279	÷ 180 600	= 1.7631	52.94	81.46
1900	324.5557	÷ 186 800	= 1.7374	54.23	82.62
1901	331.0347	÷ 193 000	= 1.7152	55.62	83.58
1902	336.1560	÷ 199 400	= 1.6858	58.00	84.43

consumption of water had dropped to 8 635 067 gallons and the per capita supply to 51.34.

From that time to within about two years the increase in the total supply has been reasonably consistent with the increase of the population supplied.

Lately a new tendency is shown to dispose of a greater per

capita supply of water. This seems to be accounted for by the effect of electrolysis which has a destructive action in several places in the city. On one street several street mains have been taken out in two successive years, being badly decomposed and one of which had been completely eaten through. The iron bolts of meters have been eaten off and replaced by composition bolts. Lead service pipes have also been badly eaten. The conditions favoring the destructive action of electrolysis are being changed steadily for the better and it is hoped that the waste of water from this cause may be kept within reasonable limits.

It is believed there is a considerable waste in connection with the direct service to elevators from the pressure in the mains. One hundred and sixty-nine elevators are supplied in this way and the condition of their supply is now being examined.

The working force in the Meter Department in Providence consists of three men, who do all the setting and repairing of the meters on the system. The total expense of the department is more than returned to the city by the charges against the takers, they being at a fixed rate per meter for the usual operations. The average annual cost per meter for repairs is about eleven and one-half cents, the total cost for the last full year reported being \$2 278.89.

Fourth. — Eternal vigilance is as necessary in a water department as in other matters, to secure a perfect result. It is found in Providence that there are men so lost to the dictates of a good conscience that they will tap in a supply back of the meter so as to draw water without having it measured.

Water is supplied to manufacturing establishments for fire purposes without cost when contained in pipes laid at the expense of the establishment and not connected with any other means of supply. It is a condition of such supply that no water whatever shall be drawn from these pipes except to extinguish fires. It was found at one time that about a million gallons per day extra was being drawn in a manufacturing section of the city and an inspector was sent out to locate the waste. It was found that two establishments near each other had opened their fire service pipes and were using the water for washing and other purposes. The fact that the combined use of the two was so great, facilitated the discovery.

Other surreptitious use of water has been discovered from time to time, like its use for broad irrigation, etc.

Nearly all the evils of waste can be cured by placing a meter on every service. It would hardly be expected in any community that illuminating gas would be furnished to takers except through a meter, notwithstanding the fact that gas is cheaper than water. In Providence gas is sold at \$1.10 per thousand cubic feet while for water \$1.50 per thousand cubic feet is paid.

DISCUSSION.

PRESIDENT WALKER. Well, gentlemen, that paper is a whole water works in itself. Does anybody want to make any remarks or ask any question? If so, please do so. Don't be afraid to ask the gentleman questions, he is able to answer them. I have been very much interested to notice that he seems to think that folks are not altogether honest in Providence, any more than they are in Manchester.

MR. H. G. HOLDEN. Mr. President, I would like to inquire of Mr. Shedd the amount and kind of lead used in a 2-inch bell.

MR. SHEDD. It is the ordinary soft lead that is used in laying water pipes, suitable, of course, for calking. It is laid a little more than three-quarters of an inch in depth, and the gasket makes up an inch or an inch and a quarter of the depth of the bell, and that is driven home until it will receive pretty good blows of a hammer without a depression in the gasket. I have found by a number of observations that it is almost impossible, in the ordinary lead used for making joints in water pipes, to have any apparent effect on the lead by any calking hammer more than three-quarters of an inch below the surface, as the lead seems to remain just as it is run, and it is not compacted in any degree below that depth, so far as I can discover, by the calking.

MR. HOLDEN. What amount of lead would be ordinarily used?

MR. SHEDD. Well, I do not carry that in my mind — it is less than the lead ordinarily used — but it is known. We have kept a very accurate account of the amount used in that way, and I have the figures, but I do not remember them. The amount of lead is carefully watched, of course, when the work is done by contract, and the inspector does not allow any less lead than the

specifications call for to go into the joints, but what the amount is, I do not remember.*

MR. GEORGE E. WINSLOW. Mr. President, I should like to ask Mr. Shedd in regard to the meters: Are they owned by the city or are they owned by the consumer?

MR. SHEDD. They are owned by the consumer, — by the water taker, but they are not allowed to be placed except by the city. The city approves of the meters, and sets them, and makes a charge for setting them to those who apply for them. The meter must be one which is approved by the city. There are three or four kinds of meters which are set by the city, and a person is allowed to make his choice from those kinds, but the meters are owned and maintained by the takers, so far as paying the money is concerned. They are managed by the city, put in by the city, repaired by the city, and the cost charged to takers for expenses.

MR. WINSLOW. What is the life of a meter, and under what conditions are they replaced?

MR. SHEDD. They are replaced at the expense of the taker, but the life of a meter — well, we have had some of them in there over thirty years, and apparently they are just as good as ever. There are meters there which were set at the beginning, and very few have failed; and this eleven cents I spoke of covers the maintenance.

MR. V. C. HASTINGS. How often, Mr. Shedd, do you test a meter?

MR. SHEDD. As often as there appears to be any reason for it. From the amount of water that is passed through, which is always observed when the inspector reads the meter at intervals of six months, it is discovered whether the meter runs freely or not.

*The calculated maximum width of lead joint and the weight, for each diameter of pipe, is as follows:—

<i>Diam. of Pipe.</i> (Inches.)	<i>Width of Joint.</i> (Inches.)	<i>Weight.</i> (Pounds.)	<i>Diam. of Pipe.</i> (Inches.)	<i>Width of Joint.</i> (Inches.)	<i>Weight.</i> (Pounds.)
4	1 $\frac{1}{8}$	3.31	20	1 $\frac{7}{8}$	21.14
6	1 $\frac{1}{4}$	4.73	24	2	28.33
8	1 $\frac{1}{2}$	6.53	30	2 $\frac{1}{4}$	37.32
10	1 $\frac{3}{4}$	8.56	36	2 $\frac{1}{2}$	50.45
12	1 $\frac{7}{8}$	10.84	48	3	105.83
16	1 $\frac{9}{16}$	15.85			

MR. HASTINGS. I suppose if a man gets a big bill he would naturally want his meter tested?

MR. SHEDD. He naturally would. I got a notice yesterday of a big supply of water upon my house.

MR. EDWIN C. BROOKS. I would say, bearing upon the depth of bells, that we recently took out some water pipes in Cambridge which were laid in 1857, and the depth of bells in the Scotch pipe, cast in 9-foot lengths, was 7 inches (see Fig. 3). Quite a difference between that and 2 inches.

MR. JOHN C. CHASE. Mr. President, I should like to ask Mr. Shedd, if in estimating population between census years he



FIG. 3. SECTION OF BELL OF OLD WATER PIPE IN CAMBRIDGE.

added a certain per cent. for the growth of the population each year. If he can answer it, I should like to know what the additional per cent. was per year, and how it checked at the census periods?

MR. SHEDD. It came very close. We kept the population in a profile, going back as far as we had any population figures; and we have five-year periods of census taking; and every year the population is taken for the school census. When we have projected the line for five years, our projected line comes very close to the return actually found by the official census. The population given in my table runs from 102 900 in 1877 to 199 400 in 1902. That is not the population within the municipal limits, because we supply outside territory, and there are certain figures that we take from our own records.

MR. GEORGE F. CHACE. Mr. President: I should like to ask Mr. Shedd if he does not find it difficult with the shallow bells to get around curves.

MR. SHEDD. No. The possible turn of the pipe is greater,

without making a leaky joint, with the shallow bells than with the deep bells. You can see that if the deep bell pipe is turned, you don't have thickness enough for the lead joint on one side of the pipe. It is one of the chief advantages of the shallow bell that you can lay it with a greater curvature.

PRESIDENT WALKER. I want a bell from three and a half to four inches deep, to run around curves almost anywhere, but Mr. Shedd gets along with these short bells. I have been using three and a half inch to four inch bells, and I don't want to shift over, because there are a good many places where if I hadn't had a long bell I should have been up all night.

MR. SHEDD. We can show you three hundred and forty miles of short bells.

MR. CHARLES N. TAYLOR. My experience has been that I could get around a long curve with a long bell, as one edge of the spigot will be almost at the bell. I do not see that there is any disadvantage in having a long bell, but the thinner the lead, the stronger it is; that is my experience. I have had both kinds, and in order to lay around a sharp curve, I prefer a good-sized bell.

MR. ALBERT F. HILL. If I am going to have a pipe laid by contract, I want the bells a little longer than two inches. Unless the contract work is watched pretty closely, you will have a good many leaky joints with 2-inch bells, but they can be watched closely enough so you can get the joints tight. We have had a good many leaks where the work has been done by contract, if it was not inspected closely enough. If I lay the pipe myself I had as soon have a 2-inch bell as any other. I think a 3-inch bell is just about right.

MR. E. S. LARNED. As to the amount of water, of which we hear so much, and the remedies which are offered, it occurs to me that the majority of municipal engineers, or water-works engineers, are pretty well advised as to what is a requisite supply. While meters will bring to the minds of many people how much water they use there is a very large number in every wealthy community to whom it makes very little difference what the meter registers. Now, that is a class of waste which I think will in time demand very serious attention. It occurs to me that it might be a good thing, in order to determine what is a necessary and requisite supply, to fix a sliding scale, which will accordingly

result in increased revenue. It will draw attention of the people who insist on wasting water to the necessity of economizing.

MR. W. H. RICHARDS. Mr. President: I think the requisite supply varies with the place. That is, a city like Woonsocket, for instance, might have a very low per capita supply, being a manufacturing place, and where perhaps four or five families use one faucet, in some cases. Whereas, in another place, like Newton, for instance, where almost every family has a large number of fixtures, their per capita consumption would be naturally very much larger. So the per capita amount would depend on the city and on their method of using water. I think each place would have to be "a law unto itself."

As to the cost: The cost per thousand gallons of course varies in every city, and you would not want to get your meter rate below the cost of furnishing the water, certainly.

MR. R. C. P. COGGESHALL. Mr. President: I would like to ask Mr. Shedd if in his analysis of the Providence conditions he ever tried to account for all the water that was used, and if there was not quite a percentage that was apparently going to waste or that could not be accounted for. I know that Mr. Kieran of Fall River has for a number of years kept such an account, and while their per capita consumption is very low, still there is a large portion which he cannot account for, in spite of all the care that is taken to keep an accurate account of all the meters used. We all know that there is a certain leakage that is silently going on here and there in the ground, even under the best conditions. We know that in large manufacturing establishments, in large cotton plants, such as I have in my city, with meters on the pipes, there is a certain amount of water sliding away on Sundays. It is not very large, yet it amounts to a good deal in twenty-four hours. I don't know but Mr. Shedd has made some observations in that direction.

MR. SHEDD. It is unquestionably true that there is a loss of water in any distribution system and that it will be much less in some places than it is in others, depending upon the manner in which the distribution is made. Our consumption of water per capita is measured by the total amount of water pumped, and the quantity supplied by the pumps divided by the population supplied gives the per capita amount used, and that, of course, includes all the waste, the loss by leakage in distribution system.

MR. COGGESHALL. Then aside from the sum total of all the meters there is something left which you cannot account for?

MR. SHEDD. Yes; if we had 100 per cent. of our services metered, then perhaps we could.

MR. COGGESHALL. I believe that Mr. Robertson is here. Perhaps he will tell us something more definite about the Fall River supply.

MR. W. W. ROBERTSON. I did not come prepared, and memory is a very unreliable source of information in a meeting of this character. I can only speak in a general way, and say that for a number of years we have had a very systematic method, I think, of determining the amount of water used and the total pumpage accounted for. The houses are ninety or ninety-five per cent. on metered service, and for twenty or twenty-five years we have been increasing the number of meters. They are very popular in the city. They are purchased by the water takers, and there is no very great difficulty in inducing the water takers to take meters.

The rates were originally so high that in 1893 there was a sliding scale adopted by which there was a reduction of rates from 21 cents down to $7\frac{1}{2}$. The reduction in rates is conducive to economy.

We had a great deal of waste from tank closets. That is the greatest source of waste we have had, but in later years we have paid attention to the waste problem and tried to regulate it. We put meters on our public buildings and found in that way how much water was used by the city departments. Every year we published a table showing the total of our investigations for that year, and the result is that we have supplied water quite economically.

At this time I cannot give you any figures. I can only refer you to our report and the table that has been contained in it from year to year for several years.

MR. COGGESHALL. I think at this point some of you will be interested to hear what Mr. Thomas has to say about what he has found out in regard to some corporations that have fire pipes, but do not use any water, — how much water is going through them.

MR. R. J. THOMAS. We have not found out how much water the corporations are using for fire service, because we haven't had meters, but the water board has determined to have meters

for fire service. There are about ten large corporations in the city that use the city supply as a secondary supply in the case of fire. When there are defective check valves it allows their water to pass into our mains, and we found it necessary for the health of the city to shut the valves on the branches that lead into the corporations, fifteen in all. Since shutting off these valves our consumption has fallen off from a quarter to half a million gallons a day.

That is all we know about it at the present time, but we expect to find out whether other concerns have these extraordinary, special privileges of having city water on their premises to put out fires without paying for it, and how much water they are using. That is what we are working on now.

MR. GEORGE CASSELL. Mr. President: I would like to ask Mr. Shedd what disposition was made of the cases he found in his city where they were using water improperly.

MR. SHEDD. Of course the first thing was to stop it, and that was done immediately; but to what extent any punishment has been inflicted, I do not know. That is in the hands of the Commissioner of Public Works.

MR. E. C. BROOKS. Mr. President: Bearing upon what Mr. Richards said about the different character of the cities, I would say that in Cambridge last year, with only six per cent. of the services metered,—and those almost entirely manufacturing supplies,—our sales by meter amounted to $37\frac{1}{2}$ gallons per capita, more than the total consumption of Fall River, a city larger than Cambridge by some eight or ten thousand. So that I think the character of the city in determining what is possible in a low consumption of water is to be taken into account.

This year we will add to that probably not far from three gallons per capita, so that this year our per capita consumption by meter, almost entirely for manufacturing, will be a little rising forty gallons.

I would say here that if any of you have public buildings that you are furnishing water to free of charge, I think it would be a revelation to find out what the consumption of water is in the ordinary schoolhouse. We have a grammar school in our city, not a very large school, but it has used a million and a half gallons of water the past year, making a per capita use of water by the school children that is perfectly enormous. I find that every-

where where the city uses water in public buildings without making any payments to the water department for it, the consumption is very large. Nothing that I have ever found has exceeded in crudeness the management of the ordinary sanitary fixtures in schoolhouses. They are given almost no supervision, and the water is allowed to run continuously.

MR. COGGESHALL. I think we can take the cake on school-house water in New Bedford. In some of the schoolhouses they were using electric motors for running their ventilating fans, but, the water being free for city uses, they installed water motors instead, which use at the rate of some 150 000 gallons a month. It costs the school nothing, and therefore they reason that it costs the city nothing; and the city allows it to go on.

MR. F. N. CONNET. The question was asked a short time ago: What is the average difference between the total reading of the meters and the total amount of water used. In the northeastern corner of New Jersey there is a private water company, managed by one of the members of this Association, and he told me a few days ago that 98 per cent. of his services were metered, but that the meters accounted for 28 per cent. less than the plunger displacement of his pumps.

I want to say a word about the difficulty of ascertaining the amount of water used by a large corporation without a meter. I know of one instance in our own city where it was estimated that the consumption was 50 000 gallons per day, but a meter was put on a few months ago, an 8-inch meter, and the consumption was found to be 280 000 gallons a day.

Now, one other thing. If you noticed the tables Mr. Shedd read, some years ago the population of Providence was about 110 000 and the per capita consumption was about sixty, I think. Last evening I was talking to a man who owns a private water company in the northeastern corner of Pennsylvania, where the number of inhabitants supplied was about 110 000, but the total water supplied per day is between 25 000 000 and 30 000 000 gallons; in other words, the total consumption per capita is from 225 to 250 instead of 60 gallons.

MR. SHEDD. There is, in what I gave, an illustration of the difference between different cities in the quantity of water required per capita, in that about half the takers in Providence are fur-

nished with water at the rate of less than 20 gallons per capita, and the difference between that and 58 gallons per capita is made up in the manufacturing portion of the water supply. In Providence we have, I suppose, an unusually large amount of water required for manufacturing purposes.

MR. CHASE. Mr. President, some of this difference in relation to the per capita consumption in different cities can be explained by the percentage of the population that is supplied with water. If you had cities where every family in each city was supplied with water, then the statistics would be of some value for comparison. The city of Providence has a matter of 85 or 90 per cent. of its population supplied, and the city of Cambridge has 95 per cent., so there would be some difference in the per capita figuring. Then, the slip of the pump is a very important factor, to my mind, and the case cited, I believe, by Mr. Robertson is not an uncommon one. It has been reported to me in several similar cases, where meters were used to a very large extent, that there was practically a very large percentage of the water that was pumped which was not registered by the meters; and that brings up the question as to whether the slip of pumps in general is not very much greater than they are credited with. I might, if the hour were not so late, give you a little personal experience. I would, however, like to ask Mr. Shedd if he wishes to express any opinion in regard to the slip of pumps.

MR. SHEDD. A pump well kept up, well cared for, and originally well constructed, should go through a long period with no more than about 2 per cent. of slip, but I know of pumps which have up to $4\frac{1}{2}$ per cent. of slip. In our case we have kept them within about 2 per cent. of slip, and when they are new I have had measurements made where we had between 1 and $1\frac{1}{2}$ per cent. of slip, when everything was in the best condition. I presume, as a matter of fact, that it varies from 2 to 5 per cent. in different places.

MR. DEXTER BRACKETT. I should like to ask Mr. Shedd in what way the slip was determined.

MR. SHEDD. By measuring all the water delivered by the pump by a weir, and then measuring the pumpage in the usual way, by the stroke of the pump and the area of the plungers. But the amount of water sent through the force main is measured over a weir, and that gives the amount of water actually delivered.

MR. BRACKETT. I wished to ask whether you had means of measuring over a weir the quantity delivered by the pumps.

MR. SHEDD. That is the way of determining it.

MR. BRACKETT. I am surprised that the slip of a pump after being used for several years was not more than 2 per cent. I think such conditions are the exception rather than the rule.

MR. SHEDD. I don't think so. Of course it is expected that the condition of the pumps will be kept up as nicely as possible. After several years of use I have not personally measured the amount of slip, except in this case, where I have found $4\frac{1}{2}$ per cent. slip.

MR. BRACKETT. I have personally measured pumps where there was 50 per cent. slip, and I have known of others where there was 40 per cent., and the slip of pumps used on the Metropolitan works has been found to be from 3 to 18 per cent. With an outside packed plunger pump, there is very little slip or leakage by the plunger, but the rubber valves wear with years of use, and as the valves wear there will be an increase in the amount of slip. You seldom get less than 1 per cent. slip with a new pump. I do not, however, think that it is safe to assume, because there is a large difference between the amount registered by the house meters and the quantity determined by the displacement of the pump plungers, that this is slip.

MR. FOSTER. My experience with pumps has been such as to bear out Mr. Shedd's view. I think that the slip of a pump ought not to be more than 2 to 5 per cent., and I think I am quite prepared to understand Mr. Brackett's having found a slip of 40 per cent. or even 50 per cent., but I do not think that is very good engineering. Of course we all know that there can be only two ways for the pump to slip, — that is, by the water passing the plunger, or passing the valve, — and that brings up the question of the design of the pump and the design of the valve and the nature of the packing of the plunger. I do not think any pump ought to be built with rigid ring packing for anything except very low heads, although I do think that a pump can be operated successfully for a great many years without showing more than a 5 per cent. slip on a solid ring for a head of twenty feet; but I think the slip of a pump goes up very rapidly after a time, if put under a high head.

My experience with the Worthington Company extends over sixteen or seventeen years, and during that time we had some tests of old pumps. One in particular I know had been in use eighteen years, and we had a careful test made of that pump. The valves had been kept in good order and the plungers showed little wear, and we found but 5 per cent. slip in that pump.

I think the question of valves is very often neglected in pumping stations, because the pumps are required to run almost all the time in some places, and the valves are not overhauled often enough. If the valves are overhauled and kept in good order, I am sure you will not find any slip of the valves to amount to anything, — not more than one-half of one per cent.

MR. F. W. DEAN. In regard to this matter of slip, I had occasion to test the old Morris engine at Lowell. I believe I made two tests. It had been in use a great many years, and, if I remember rightly, the slip was found to be in the vicinity of 5 per cent. The water was measured over a weir, and I am under the impression that very little had been done to the pump end during the life of the pump up to that time.

I have been recently informed that in New York the slip has been found to be, if I remember rightly, something like 36 per cent. on one pump, and various amounts less than that on some of the others.

MR. J. C. WHITNEY. I think Mr. Shedd said that the repairing of 20 000 meters cost about \$2 200 a year and that it took the services of three men. Now, if Providence pays ordinary machinist wages, how are the necessary repairs borne out of that sum?

MR. SHEDD. Those three men had a great many other things to do besides repairing meters; for instance, they set all the meters and take the readings.

MR. WHITNEY. There is also another question. I think Mr. Shedd stated that by experiment he found a certain composition gave the best satisfaction in the service supply district. Will he be kind enough to state what it is?

MR. SHEDD. The mixture used is in the proportion of 80 pounds of copper, 6 pounds of tin, 3 pounds of zinc, and 2 pounds of lead. The use of lead is for the purpose of securing smooth and easy work in the machine shop.

IMPROVEMENTS IN ECONOMY OF PUMPING ENGINES.

BY F. W. DEAN.

[Read November 11, 1903.]

In 1893 I read a paper before this Association giving the briefest notice of some of the oldest types of pumping engines, and an account somewhat fuller of the then prevailing types of pumping engines in the United States. The presence here to-day of Mr. J. Herbert Shedd reminds me to speak of the Cornish engine that was installed in the Pettaconsett Pumping Station of the Providence Water Works when Mr. Shedd designed that system, and of the connection of that time with the fascinating period of Cornish engine prominence in England in the person of Mr. Simeon Noel, the talented engineer whom Mr. Shedd imported from Cornwall to take charge of his engine near Providence. Mr. Noel was one of those thorough Cornish engineers, trained by years of apprenticeship and as engineer in charge of large engines of his favorite type in Cornwall, whom it was a satisfaction to meet. It would be a matter of regret if his name should be forever unmentioned after his death, which took place a number of years ago, and it would be a pleasure to hear some account of him from Mr. Shedd.

I remember how much Mr. Leavitt enjoyed calling on Mr. Noel at the Pettaconsett Pumping Station and conversing upon the topic uppermost in both of their minds. I believe that Mr. Noel was employed at the Fowey Consols Mines in Cornwall when, in 1840, a Cornish engine gave a duty of 120 000 000 foot pounds per 100 pounds of coal when using steam of 12.57 pounds pressure per square inch.

When Mr. Noel was at Pettaconsett, pumping engine controversies and rivalries were beginning to be rife in Providence, and a Worthington duplex compound engine of the ordinary type was put in for spare use. Mr. Noel naturally was sceptical of the success of anything but an engine of the Cornish type, but it fell to him to take charge of the Worthington engine.

Although it was entirely deficient in the grandeur and impressiveness of the Cornish engine, and enjoyed no international reputation, Mr. Noel admitted that he was surprised at the success and reliability with which it operated.

Passing from this short reminiscence to the subject of modern pumping engines, it may be remembered that about the year 1883 there was brought out a Worthington engine with an attachment devised to imitate the effect of a fly wheel, by means of which the steam could be cut off early and worked expansively, and the stroke completed notwithstanding the diminished pressure of the steam in the cylinders due to its expansion. It may not now be as improper as it once would have been to say that I feel that this engine has been a disappointment both in first cost, economy, simplicity, and satisfactory operation. There has thus far been nothing devised which will produce the effect of a fly wheel as well, or as simply, as the fly wheel itself, and I believe that ingenious mechanical minds are now turned to more promising fields of activity.

In my paper of ten years ago I gave a short account of the vertical three-crank Allis triple expansion engine. This engine has been copied by other builders and may now be called a standard type of the country. It has reached the maximum duty that has been obtained, and has the design of valves and valve gear that is indispensable for the most economical results. In my former paper I mentioned that single beat poppet valves were used by the Allis Company in the heads of the low-pressure cylinder. This valve continues to be used, and has sometimes been used in intermediate cylinders, and is used by nearly all makers. It is a circular valve on a spindle that is moved up and down by cams not unlike those used on the beam engines of side-wheel steamers. The steam inlet valves when they open move away from the cylinders, and when they are closed are flush with the face of the head. The exhaust valve is flush with the cylinder head when closed, and opens by entering the cylinder. When it opens and enters the cylinder the piston is near the other end of the cylinder, but when the piston returns the valve is closed and is out of the way.

You have, of course, all heard of the effect on economy of a small volume between the piston when at the end of its stroke and

the valve seat. This is what is called clearance volume, and the smaller it is, the greater the economy. The reason for this is that a portion of the steam which fills it passes into the condenser and is lost. It will be seen that the single beat valve makes the clearance volume the least possible and must produce the greatest possible economy, as far as it affects economy. There is another good effect of this valve. It reduces to the smallest minimum the surface of the interior of the cylinder and thereby diminishes the condensation of steam. In the case of the Corliss and gridiron valves, there is a great deal of surface around the ports, and this produces condensation.

From these considerations it will be seen that nothing can be done in future to design steam cylinders so as to increase the economy of steam.

Somewhat recently a new method of using steam in cylinder jackets and reheaters has been employed. This consists in taking boiler steam into the high-pressure jacket, thence to the first reheater, thence to the intermediate jacket under reduced pressure, thence to the second reheater, and thence to the low-pressure jacket under still further reduced pressure. Reducing the pressure in the low-pressure jacket is important, for otherwise the exhaust of that cylinder will pass to the condenser in a superheated condition, and heat is thus lost.

With cylinders designed in the best conceivable manner, and the best conceivable method of using the steam being employed, what is there left to increase the economy of steam?

There are a few things that can be done to assist. In the first place, a maker should be required to guarantee that after an engine has been run two or three months the valves and pistons should be perfectly tight. This can be determined by trial, and the valves can be scraped tight.

Another thing is that the maker should be required to guarantee a high vacuum in the low-pressure exhaust pipe near the cylinder, say no less than 28 inches. The maker should also be required to furnish a mercury column to show the vacuum instead of, or in addition to, a vacuum gage of the ordinary kind. After having once obtained a high vacuum, the engineer should be required to maintain it.

Recently much attention has been given to condensing appa-

ratus in connection with steam turbines, and more is now known about the best means of obtaining high vacua than has been known heretofore. It is of more importance to obtain a high vacuum with turbines than with reciprocating engines, but with the latter it is of sufficient importance, in the interest of economy, to insist upon the best obtainable vacuum.

It has been thought that in addition to the usual air pump an additional pump, known as a dry-air pump, should be used, whose function is to remove the air that comes through with the steam or that leaks in. Usually this air is swept along into the condenser pump, which has been called the air pump for the reason that it pumps this air. The dry-air pump simply helps the other pump along, and it is quite probable that a larger ordinary air pump would do as much good. At all events there are cases where a vacuum of 29 inches has been maintained without a dry-air pump, as in the cases of the Louisville pumping engine and the steam turbine plant at Newport, R. I.

An advisable adjunct of the high-vacuum apparatus is an air cooler, which makes the volume of air to be pumped smaller.

The most prominent means of promoting economy, however, at the present time, is the use of superheated steam. This has been in use in Europe for a longer time than in this country, and has been especially promoted in Germany. There is no doubt that it reduces steam consumption to a great extent. If we look at the records of the test of the Louisville pumping engine, for example, we shall see that while the engine as a whole used 12.16 pounds of dry steam per indicated horse-power per hour, the cylinders themselves used only 10.12 pounds. Of course this economical cylinder performance was caused by the superheating effect of the jackets and reheater. If now some external appliance could superheat the steam to such an extent that the engine as a whole would use as little steam as the cylinders did alone, the total economy of steam would be greatly improved and the duty would have been 182 000 000 foot pounds instead of 152 000 000 foot pounds per 1 000 pounds of dry steam. It would be perfectly possible to do this, and even the Louisville engine could, without doubt, be made to give a duty of, say, 180 000 000 foot pounds or even more by the use of superheated steam.

While this is perfectly true, the question arises, At what cost in fuel can the steam be superheated? On this point there is but little information available. If the steam could be superheated by waste gases from the boiler it would be all gain, but it can only be done some 25 to 35 degrees by means of the vertical type of boiler. This is, of course, advantageous, and I have been informed that the most economical cotton mills are those with Manning boilers.

There is one thing that can often be done, and it seems to me that it always ought to be, when not impracticable, and that is to reheat the steam between the cylinders by means of the gases from the boilers instead of by means of live steam. I designed such a reheater a number of years ago, but not until recently was one used. This I designed for the Barr engine at Haverhill, with the result that the duty was found on each of two tests to be about 150 000 000 foot pounds per 1 000 pounds of steam. An engine of this type and size with a steam reheater gives about 128 000 000 foot pounds duty. The gases in this case superheated the steam between the cylinders about 60 degrees F., and this it was able to do because the pressure of steam between the cylinders is so low. Here is a clear gain at no cost for fuel, and small cost for apparatus.

In regard to methods of superheating steam at boiler pressure, it can be done in connection with superheaters in the boiler setting, or in separate furnaces. In the former case sometimes the superheat varies with the intensity of the fire as determined by the damper regulator, while sometimes the superheat can be kept approximately constant by means of dampers for varying the supply of hot gases to the superheater regardless of the intensity of the fire.

Separate superheaters can raise the temperature of the steam to any reasonable amount, and these are held by many to be the most desirable form, not only on this account, but because the degree of superheat can be controlled. If they are used the fuel is quite an item, and the escaping gases should be used for heating feed water.

Tests have been recently made in Philadelphia of a Rice & Sargent compound engine, without steam jackets, with a reheater, and provided with Edge Moor water tube boilers and a separate

Schmidt superheater, by Albert C. Wood and Prof. D. S. Jacobus. The guarantee was that the engine should not use more than $10\frac{1}{2}$ pounds of steam per indicated horse-power per hour with the steam at 140 pounds and superheated from 240 to 290 degrees F. With ordinary dry steam the engine was guaranteed to consume not more than $13\frac{1}{2}$ pounds.

The following are some of the results:

Date of test, June 19 and 20.

Duration, 14 hours.

Average temperature of steam entering superheater,	367° F.
" " " " leaving "	814° F.
" " " " escaping gases,	472° F.
" " " " steam at throttle,	736° F.
" " " " " h. p. cylinder,	659° F.
" " " " exhaust at h. p. "	332° F.
" " " " steam " l. p. "	396° F.
" " " " exhaust of l. p. "	128° F.
Average steam consumption per I. H. P. per hour, with superheated steam,	9.68 lbs.
do. with saturated steam on July 24,	13.81 lbs.
Coal used per I. H. P. per hour with saturated steam,	1.41 lbs.
do. with superheated steam,	1.23 lbs.
Saving, $1.41 - 1.23 = 0.18$ lbs. =	12.7%
Applying all corrections the report calls the saving,	14.52%.

You have many times had your attention called to the different methods of stating and computing the duty of pumping engines and the arguments for them. The coal method is, of course, the commercial method, but it is obviously improper when only an engine is purchased and the maker is required to guarantee his engine. For this purpose the duty is usually based upon the consumption of 1 000 pounds of dry steam. The more proper method, although one that fails to become popular, is the heat unit method. It is more correct, because the steam engine is a heat engine, and heat does the work. The method by weight of steam is not quite right, because different steam pressures and different qualities of steam are used at different times, and therefore 1 000 pounds of steam does not always contain the same number of units of heat.

The method by heat units is somewhat laborious, and requires some knowledge of the properties of heat. It may be outlined as follows: When steam passes into a steam cylinder, or series of cylinders, it has a certain number of units of heat in each pound. This is made up of the heat of vaporization and of the

liquid of the same temperature, and if it is superheated, an additional amount. When it leaves the engine it has the heat corresponding to the temperature of the discharge from the condenser, as shown by a thermometer in the hot well. The difference between these quantities has been used by the engine. If the engine has jackets and reheaters, the same number of units of heat exists in each pound entering them, but as the condensation leaving these parts is hotter than the condenser discharge, a different number of units of heat leaves the jackets and reheaters. Subtracting the number leaving from the number entering gives the number used by these accessories, per pound. By multiplying the number in a pound by the number of pounds passing through the cylinders, and similarly with the steam passing through the jackets and reheaters, and adding them together, there results the total number of units of heat used by the engine. This sum is then used in computing the duty. While it is simple enough after one becomes familiar with it, I do not believe that it will ever become sufficiently popular to be often used.

While upon this subject I want to urge you not to specify unusual methods of computing the duty when purchasing a new engine. The reason for this is that a standard method is in force, and has for its object the existence of something with which comparisons can be made, and thus to have the means of judging of the excellence of a new engine, or of the perfection of maintenance of an old one. If a new method of determining the duty of an engine is used the result cannot be compared with the standard, and therefore there are no means of knowing whether the new engine is good or not.

RAINFALL AND RUN-OFF FROM CATCHMENT AREAS
IN NEW ENGLAND.

BY L. M. HASTINGS, CIVIL ENGINEER, CAMBRIDGE, MASS.

[Read December 9, 1903.]

The preparation of a reliable estimate of the flow or run-off which may be expected from a given catchment area is a matter often of vital interest to manufacturers, municipal officers, and engineers. Upon the correctness of these estimates may depend the success or failure of large enterprises requiring the investment of many thousands of dollars of capital, or the comfort, health, and even the lives of thousands of people dependent for water upon the adequacy of a public water supply.

Every consideration of prudence and public safety points to the requirement that such an estimate be not over sanguine in its anticipated results, else in the case of a stream developed for power, disappointment may come from a stream overdeveloped and so working uneconomically; or in the case of public water supply, the capacity of the works may be found disappointingly small, which usually means an extension and increase of the supply. It seems to be generally true that but few works have given as large a supply or have served the community as long as was at first expected.

It is wise, therefore, that all the data of value relating to the subject should be collected and the entire question studied with great care. Realizing this, the United States Government has caused an extended series of investigations to be made into the subject, the reports giving the results of which form a series of valuable papers. Some of the states — notably the state of New Jersey, in a valuable report published in 1894 — have done the same thing. The subject has also been quite fully discussed in various papers published in the *Transactions of the American Society of Civil Engineers*.

While the best method of determining the run-off from a given area is to measure the flow of the stream draining the area, yet

it is seldom possible to carry these measurements over a period long enough to be of much value in determining the average or the minimum flow — so, often, other means are necessary.

RAINFALL.

As the rainfall upon an area, its amount and distribution, is the most important element in determining the run-off, it naturally receives the largest share of attention. For a considerable period now, observations of temperature and rainfall have been kept in a satisfactory manner at many points in the country, under the auspices of the United States Weather Bureau. While these observations have not yet been extended enough in time to be taken except in the absence of other rainfall records carried over longer periods, there can be no doubt that in the future they will prove invaluable.

In New England and the eastern states many private observers have records of rainfall extending back to the early part of the last century. While into these earlier records, it is true, some errors may have crept, and while it is probable that the same care was not taken (especially in the measurement of snow) as is now required, they will, nevertheless, prove of interest, and the error, if any, may be expected to be on the side of safety in at least not overestimating the amounts.

Two interesting questions occur here: How many years' observations are required to give a fairly reliable average result? and, Within what period is the minimum rainfall liable to occur?

With regard to the first question, the longer the period considered, of course, the more reliable the result and the less will the average obtained depart from the true average. Mr. Alexander Binnie, an English engineer, in a paper read before the Institute of Civil Engineers, in 1892, on "Variation in the Amount of Rainfall," examined over 150 long-time records of rainfall obtained in various parts of the world, — the United States, Great Britain, the European Continent, and India, — and from the numerous cases cited draws the conclusion that "dependence can be placed on any good record of thirty-five years' duration to give a mean rainfall correct within 2 per cent. of the truth." For records of twenty years' duration, the error may be expected to be 3.25 per cent.

Mr. Alfred J. Henry, chief of division, United States Weather Bureau, in a paper on "Rainfall of the United States," 1896, finds by comparing some long-time records obtained in this country that at least thirty-five to forty years' observations are required to obtain a result that will not depart more than 5 per cent. above or below the true normal average.

The second question will be referred to later.

Upon Plates I and II are shown diagrammatically the annual rainfall for eight localities in full lines, while the annual average by ten-year periods is shown in broken lines.

The Lowell rainfall diagram is from records kept by the Proprietors of Locks and Canals at Lowell. The Waltham diagram is from records kept by the Boston Manufacturing Company. Providence and New Bedford rainfall are taken from a report by Mr. A. T. Safford to the Fall River Reservoir Commission, 1902. Boston rainfall, 1820 to 1891, is taken from Mr. D. FitzGerald's paper in *Transactions American Society of Civil Engineers*, 1892; for 1892-1900, Sudbury River rainfall (from report of Metropolitan Water and Sewerage Board, 1901), is used to complete the Boston record. New York rainfall, 1836-1868, is from the report of Isaac Newton on New York Water Supply, 1882; and 1868 to 1899 from the report of J. R. Freeman, 1900. Philadelphia rainfall, 1824 to 1889, is from report on geological survey of New Jersey, 1894; 1890 to 1900, from department of public works, Philadelphia.

An inspection of these diagrams will at once suggest the question, Is our rainfall increasing? Prof. Mark W. Harrington, in a paper on "Rainfall and Snow in the United States," in *Bulletin "C," Weather Bureau*, examined this question, but as the data were so contradictory and inconclusive he reached no definite conclusion. He was inclined, however, to answer the question in the negative. If the rainfall records shown on the diagrams taken in the early periods were as reliable as those obtained later, the conclusion from some of them — notably Nos. 1 to 4 — might be drawn that the rainfall *was* increasing. Some of the records, on the other hand, show that a maximum was reached in the middle of the last century, and that the rainfall is now decreasing. Attention should be called to the extremely high average shown in the Boston record for the period 1861 to 1870 the average, 57.30

inches, being far above that of any other period shown. A study of the following tabulation of the averages may also be instructive.

TABLE No. 1.

SHOWING AVERAGE ANNUAL RAINFALL (INCHES) BY TEN-YEAR PERIODS.

PLACE.	1820-1829.	1830-1839.	1840-1849.	1850-1859.	1860-1869.	1870-1879.	1880-1889.	1890-1899.
Providence . . . . .	..	36.87	41.21	43.73	47.56	47.84	49.07	48.90
New Bedford . . . . .	..	44.27	44.94	44.76	46.27	46.88	48.69	47.72
Waltham	42.25±	40.49	40.74	42.84	42.52	40.66	44.15	44.74
Lowell	40.31±	39.35	40.27	*46.54	45.93	45.24	46.46	44.47
Boston	39.61	41.18	42.92	50.03	†57.30	50.26	48.78	46.37
Harvard Observatory . . . . .	..	..	43.28	49.23	45.23	44.99	44.60	41.19
Philadelphia	38.01±	42.40	45.24	44.25	46.74	42.21	39.59	40.38
New York & Croton . . . . .	..	41.55±	42.47	48.22	53.19	44.81	51.21	48.37
Worcester . . . . .	..	..	42.80	52.46	44.35	‡41.58	42.75	42.82

*Second observing station. †Observe the abnormally large rainfall. ‡Six years 1875-1880.

An inspection of the diagrams might also suggest the query whether, in certain cases, especially in the designing of works whose life was expected to be limited to a short period, say twenty or thirty years, it might not be best to consider the rainfall average obtained from a comparatively short time.

If the rainfall in certain localities is increasing, a long period average will give too low a result; while, on the other hand, if the period of maximum rainfall has passed and it is now decreasing, the inclusion of that period of large rainfall might give too large an average.

The range or variation in the amount of annual rainfall is remarkable, especially in the Boston record, the maximum amount being 67.72 inches in 1863, and the minimum being 35.56 inches in 1883, while at Sudbury River the rainfall for 1883 is given as 32.78 inches.

Another interesting fact shown by the diagrams is that years of large or maximum rainfall recur at intervals of approximately ten years, while the years of low or minimum rainfall recur at much longer intervals.

DISTRIBUTION OF RAINFALL.

In a study of rainfall in its relation to run-off, its *seasonal distribution* through the year is important. Mr. Clemens

Herschel, hydraulic engineer, of New York, in discussing this subject says,

“Observations show, however, that the distribution of rainfall, the times and the rates at which it falls, have a most potent effect on the relation. Hence it is that years of practically the same rainfall have widely differing amounts of run-off, not to speak of the differences of yield of months and single showers having the same measure of inches of rain.”

“It is in the study of the effect of these additional factors upon the run-off of streams, in the study of effect of slopes, of the quality of surface, and to some extent of the distribution of rainfall, that the customary percentage proportions of rainfall to flow of streams, have their proper place and have value.”

The diagrams already referred to show the rainfall for the various localities and years as though it were uniformly distributed throughout the year: such of course is not the case.

The heavy full lines upon the diagrams, Figs. 1, 2 and 3, show the average rainfall by months as observed at Philadelphia, Harvard Observatory, and Sudbury River, Boston Water Works.

It is interesting to observe that the average monthly rainfall does not vary greatly, but on the whole the rainfall is rather uniformly distributed throughout the year, also that the maximum amount at Philadelphia, Harvard Observatory, New York, and many other places occurs in *August* (commonly supposed to be a dry month). Extremely large rainfalls are also recorded for this month at many stations — 15 inches at Harvard Observatory, and 16.84 inches at Philadelphia. The broken line shows in each case the rainfall of an exceptional year and indicates the wide monthly range which sometimes occurs.

RAIN GAGES.

It is often important to study rainfall for periods shorter than a month. For this purpose the records obtained by the automatic rain gage are extremely useful. Such gages are now constructed and sold at a moderate cost, are quite reliable, and give results which cannot fail to be instructive, for they record not only the *amount* of precipitation up to any given time, but they also show the *rate* at which it has occurred at any time, often an important factor. The diagram, Fig. 5, shows four records which were obtained in the summer of 1900 by an auto-

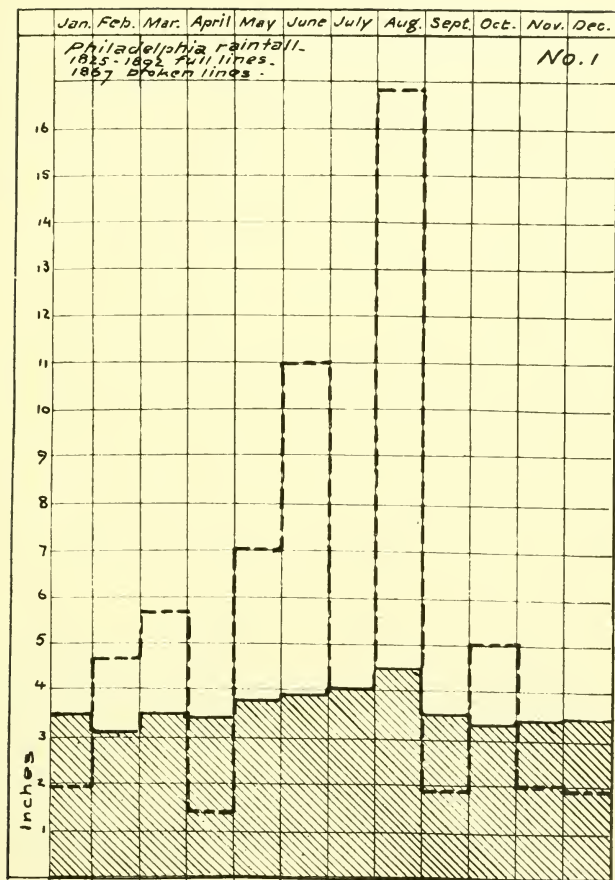


FIG. 1.



FIG. 2.



FIGS. 3 AND 4.

matic rain gage at City Hall, Cambridge, and while the total amount was not large, the *rate* was exceptionally so. The first occurred August 10, 1900, and for five minutes gave a rate of 6 inches per hour; the maximum rate of the second was 2.81 inches per hour for sixteen minutes; the third, 1.80 inches per hour for ten minutes, and the last a rate of 3.75 inches per hour for eight minutes.

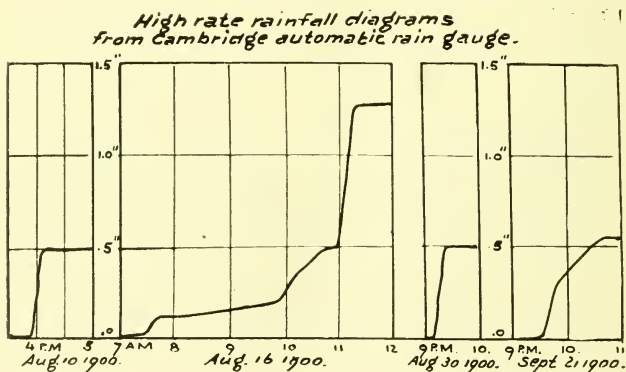


FIG. 5.

Much has been written concerning the curious fact that the elevation of the gage above the ground has a marked influence on the amount of rainfall received in the gage, the elevated gages recording less than those placed at or near the ground. This difference amounts in some cases to 10 to 15 per cent. for small elevation, say 20 feet, while for elevations of 150 feet the difference may be 50 per cent. Attention was first directed to this fact by an English scientist, Heberden, in 1769, in a paper read before the Royal Society of London.

No entirely satisfactory explanation of this has as yet been given, but it is generally believed to be due largely to the effect of wind playing about the receiver of the rain gage. Professor Nipher of St. Louis claims that with a suitably constructed wind

guard or shield the gages will record the same, regardless of their elevation.

This subject has been discussed by Mr. D. FitzGerald in a paper read before the Boston Society of Civil Engineers, August, 1884, and recently by Prof. Cleveland Abbe in a report to the United States Department of Agriculture. As but little attention has been paid to the effect of the elevation of the gage upon the amount collected until recently, it seems not unlikely that some of the older records are more or less inaccurate for that reason.

EVAPORATION.

Since the major part of the water falling on the land must flow from it or be evaporated, the matter of evaporation is closely allied to that of rainfall, especially if there are large water surfaces contained in the catchment area. It is supposed that the annual evaporation bears some relation to the mean annual temperature and the rainfall, and thus having these two quantities given, the run-off can be computed.

Mr. C. C. Vermeule, in a report to the state geologist of New Jersey, 1894, suggests an ingenious formula expressing this relation. This formula he has modified slightly in a subsequent report on forests in 1899. While the results given by it agree quite closely in some cases with the observed quantities, in others a considerable difference is noted, showing that the formula is useful only when the conditions are similar to those from which the formula was deduced.

The evaporation from water surfaces has been extensively studied in this country. As is well known, Mr. FitzGerald carried out a very elaborate series of experiments and observations to determine the amount and the law of evaporation from water surfaces, and described the same in a paper found in the *Transactions of the American Society of Civil Engineers*, 1886. Mr. Arthur T. Safford, C.E., in a report on the water supply of Fall River, Mass., 1902, reports observations of the evaporation during the years 1899, 1900, and 1901, near that city. Observations have also been carried on at New York, Philadelphia, and other places.

The mean annual evaporation given by Mr. FitzGerald is 39.12 inches, or 85 per cent. of the mean annual rainfall.

Little experimental data seems to be available of the evaporation from the soil in this country. Mr. J. T. Fanning, in his treatise on "Water Supply Engineering," quotes some English experiments on evaporation from the soil. One set at Whitehaven, England, 1844 to 1853, gave an evaporation of 29.21 inches, with a rainfall of 43.50 or 69.1 per cent. Another at Lee Bridge, 1860 to 1873, gave an evaporation from soil of 19.534 inches on a rainfall of 27.7 inches, or 70 per cent. None of these figures probably include the water absorbed and transpired by vegetable and plant life.

In the absence of experimental data to determine the evaporation from land, the total loss by evaporation, absorption by plant life, and percolation, may readily be determined in streams where the run-off has been observed, and indeed, this method is in many respects more reliable than any experimental observations could be, as it may be carried out on a large scale under conditions as they actually occur in nature.

TABLE No. 2.

SHOWING LOSS BY EVAPORATION, ETC., ON SUDBURY AND CROTON RIVER AREAS.

Month.	Sudbury River 1875-1900.			Croton River 1868-1899.			Sudbury River 1883.			Croton River 1880.			Water Surface Evaporation (Inches).
	Rainfall (Inches).	Run-off (Inches).	LOSS Evaporation, etc. (Inches).	Rainfall (Inches).	Run-off (Inches).	LOSS Evaporation, etc. (Inches).	Rainfall (Inches).	Run-off (Inches).	LOSS Evaporation, etc. (Inches).	Rainfall (Inches).	Run-off (Inches).	LOSS Evaporation, etc. (Inches).	
Jan.	4.35	2.20	2.15	4.20	2.69	1.51	2.81	0.60	2.21				0.98
Feb.	4.44	3.17	1.27	4.13	2.99	1.14	3.87	1.66	2.21				1.01
Mar.	4.48	5.23	0.75	4.03	3.91	0.12	1.78	2.87	1.09				1.45
Apr.	3.22	3.44	0.22	3.18	2.98	0.20	1.84	2.33	0.49				2.39
May	3.37	1.95	1.42	3.78	1.84	1.94	4.19	1.67	2.52				3.82
June	2.93	0.81	2.12	3.36	0.87	2.49	2.40	0.52	1.88				5.34
July	3.72	0.34	3.38	4.87	0.60	4.27	2.68	0.20	2.48				6.27
Aug.	4.09	0.53	3.56	4.87	0.99	3.88	0.73	0.14	.59				5.97
Sept.	3.24	0.41	2.83	4.02	0.84	3.18	1.52	0.16	1.36				4.86
Oct.	4.35	0.93	3.42	3.80	0.94	2.86	5.60	0.33	5.27				3.47
Nov.	4.27	1.62	2.65	4.12	1.72	2.40	1.81	0.35	1.46				2.24
Dec.	3.55	1.86	1.69	3.71	2.13	1.58	3.55	0.35	3.20				1.38
Total	46.01	22.49	23.52	48.07	22.50	25.57	32.78	11.18	21.60	36.92	12.63	24.29	39.12

In Table No. 2, the losses by evaporation, etc., for the Sudbury and Croton River areas are shown, together with the average evaporation from a water surface, as given by Mr. FitzGerald. From this it appears that the total losses from a land surface are but 60 per cent. of the evaporation from a water surface. It is interesting also to note the close ratio the total loss has to the rainfall in the two areas compared. The average on the Sudbury is 51.1 per cent. and on the Croton 53.2 per cent., while for the year of lowest rainfall, 1883, on the Sudbury, it was 66 per cent., and for the lowest year on the Croton, 1880, it was the same — 66 per cent.

This relation of rainfall, run-off, and loss on the Sudbury River area is also shown graphically on the diagrams, Figs. 4 and 6, where the rainfall is shown in two parts, the heavier shaded portion representing the run-off, and the lighter shaded portion, the loss by evaporation, etc.

The exceedingly small mass of run-off in July, August, and September illustrates the dryness of these months and the value of storage reservoirs to enable the surplus run-off of the preceding months to be carried over and used then to bring up the low flow.

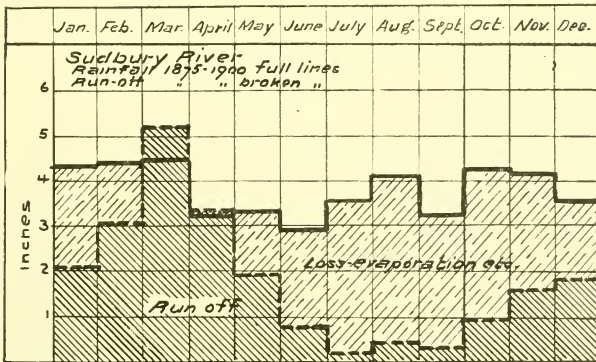


FIG. 6.

It seems to be a fortunate provision of nature that the annual amount of evaporation does not vary greatly from year to year.

Thus, the loss on the Sudbury River area for 1883, the dryest year recorded there, varied less than 2 inches from the average loss for twenty-six years; and the same is true of the Croton River area.

Mr. George W. Rafter, in an excellent paper on the "Relation of Rainfall to Run-off," *United States Geological Survey*, 1903, in speaking of what he calls the "persistency of rates of evaporation," says :

"The persistency of the amount of evaporation for any given stream at about the same figure through long periods of time was first pointed out by Messrs. Lawes, Gilbert, and Warrington in their classical paper, "On the Amount and Composition of Rain," etc., in 1881.

"As to *why* evaporation exhibits such persistency, these distinguished authors consider it largely due to the fact that the two principal conditions which determine large evaporation — namely, excessive heat and abundant rainfall — very rarely occur together. The result is, especially in the English climate, a balance of conditions unfavorable to large evaporation. In a wet season, when the soil is kept well supplied with water, there is at the same time an atmosphere more or less saturated, with an absence of sunshine, while in dry seasons the scarcity of rain results in great dryness of the soil, with scant, slow evaporation."

MAXIMUM RUN-OFF.

The maximum run-off from an area has little commercial value, and is important to study principally in the designing of works which will remove the flow without damage. In the construction of sewers, culverts, water courses, and spillways for dams, it is of the utmost importance to determine the maximum rate of flow which may be expected, that their capacity may not be over-taxed and serious damage result. In the determination of maximum rates of rainfall on comparatively small areas as a preliminary to estimating the maximum rate of run-off, the use of an automatic rain gage will be found of great service. Having determined the maximum rate of rainfall for the length of time it takes the flood wave to reach the culvert or sewer outlet, the rate of discharge or maximum run-off may be computed with fair accuracy by the use of formulas, with the aid of coefficients adapted to meet the conditions of the case in hand. In the city of Cambridge, for instance, it was found that for twenty-minute

periods the maximum rate of rainfall to be expected was 2.5 inches per hour, and so all storm-water drains, culverts, etc., are designed to take the flow produced by that rate, using to determine this flow, the formula proposed by Burkli-Ziegler and adapted by Rudolph Hering, adopting a variable coefficient suited to the character of the surface of the area considered.

In most cases actual gagings of a stream or water course of this character are extremely difficult, as the effect of a sudden shower or burst of rain is soon over and the "flood wave" gone.

In cases like this, self-registering gages are of great service. Interesting results have been obtained by their use at Cambridge and at Hartford and Philadelphia, in connection with sewer work undertaken by these cities.

Of the flood flow from large areas, little exact information can be given. Mr. Vermeule, in his report already referred to, has compiled a table which gives the maximum and minimum flow from many areas of varying sizes. Some of the figures are here reproduced, the areas being arranged in the order of sizes. In general, it may be said that the larger areas give smaller rates of flood flow, while the smaller areas give smaller rates of minimum flow. This tendency is also referred to in the comparison of the flow from New England areas farther on in this paper.

STREAM.	Catchment Area, sq. miles.	Maximum Flow, cu. ft. per sec. per sq. mile.	Minimum Flow, cu. ft. per sec. per sq. mile.
Ohio River	19 000.0	6.17	0.114
Potomac River	11 476.0	15.25	0.093
Connecticut River	10 234.0	20.27	0.510
Kanawha River	8 900.0	13.49	0.123
Delaware River	6 770.0	37.50	0.170
Merrimac River*	4 664.0	20.87	0.310
Raritan River	879.0	59.50	0.200
Passaic River	796.9	24.20	0.190
Concord River	361.0	12.32	0.170
Croton River	338.8	74.87	0.150
Ramapo River	159.5	66.10	0.140
Perkiomen River	152.0	34.90	0.050
Neshaminy River	139.3	41.40	0.009
Tohickon Creek	102.2	54.30	0.001
Sudbury River	75.2	41.38	0.036
Croton River, West Branch	20.3	54.44	0.020

* Including Nashua, Sudbury and Cochituate catchment areas, amounting to 213 sq. miles.

MEAN RUN-OFF.

In estimating the flow of a stream for power purposes the mean or average flow is of importance, as it is then desired to know the maximum flow of the stream in an average year to which it will be wise to develop the power and construct the wheel plant, so that as full use of the water power as is possible may be made; also, how much below this maximum or "full power" will the stream fall during dry times, when water power will have to be supplemented with steam. Here, again, long-time gagings of the stream itself are the most reliable of any data. Sometimes gagings of a stream similarly situated may be used and applied to the case, or, if no gagings are obtainable, but a good rainfall record is to be had, the probable run-off can be computed from that by formula. Mr. Vermeule, in his report, has suggested a method by which this may be done.

Probably the average flow of streams and their value for power and manufacturing purposes are matters about which more litigation has been had than any other question in hydraulics. Many communities of New England and their water-works officials have had occasion to know and appreciate the value of water as power from the numerous suits brought to recover damages, by reason of the diversion of said water for domestic purposes.

MINIMUM RUN-OFF.

For water-works purposes the minimum seasonal run-off from an area is of the most importance, and it is the question which should be given the most consideration. As most water works have storage reservoirs of more or less capacity, the absolute minimum flow for a few days is not of so much importance as the length of time a low or minimum flow may continue. It is a fact to be remembered in this connection that the year of lowest rainfall may not give a period of lowest run-off. The *distribution* of the rainfall has an important effect on that question. Mr. Rafter, already quoted, says that

"the total run-off of a stream in any given year depends very largely on the run-off of what may be called the 'storage period.' Usually about 0.75 or 0.85 of the total rainfall of this period appears as run-off in the stream, while for summer, or the growing period, not more than 0.10 of the rainfall appears. This great difference is due to greater evaporation as well as to the absorp-

tion of water by plants during this period. Whether any given stream is low during the summer months, or has then a well-sustained flow, will depend very largely on the rainfall of *May*. When the May rainfall is heavy enough to produce full ground water, the flow is likely to be well sustained, even though the rainfall is comparatively low during the summer months following. If, on the contrary, the May rainfall is so low as to leave a deficiency in ground water for that month, the flow will be low during the summer, even though the rainfall is large. What is wanted, therefore, in a stream is as large a ground flow as is possible, with small evaporation."

Upon the diagram (Fig. 6) is shown the average rainfall for the Sudbury River area, 1875 to 1900, and by broken lines is shown the run-off for the same period, expressed in inches. In March the run-off exceeds the rainfall, while for the six months from June to November the run-off is much less than the rainfall, due to losses by evaporation, absorption by vegetation, etc.

There is a marked difference in the *percentage* of rainfall appearing as run-off, between years of large and years of small rainfall, especially if in the area there are large water surfaces. Thus in the Sudbury River area, with 6.5 per cent. water surface, the average run-off is 48.8 per cent. of the average rainfall, while in 1880, with a low rainfall, only 31.8 per cent. ran off. In a year of large rainfall 62.2 per cent. was collected. On the Croton River, N. Y., area in 1868, 66.2 per cent. of the rainfall was collected, and in 1883 only 31.2 per cent. was collected.

An inspection of the rainfall diagrams on Plate I will be of interest regarding the question of frequency and duration of periods of low annual rainfall as affecting minimum run-off.

If 35 inches be taken as the measure of extreme low rainfall, it is found that annual rainfalls not exceeding that have occurred as follows:

Waltham	.....	8 years	1825	1844	1846	1874	1879	1880	1882	1883
Harvard Observatory	5	"	1844	1846	1866	1883	1894			
Boston	.....	4	1822	1828	1837	1846				
Providence	.....	5	1833	1835	1837	1846	1849			
New Bedford	.....	1	1846							
Lowell	.....	7	1826	1834	1835	1837	1846	1891	1894	
Philadelphia	.....	9	1825	1834	1856	1878	1880	1881	1885	1890 1895
New York & Croton	. 5	"	1836	1840	1842	1845	1849			

From this it appears that it is but rarely that two years of low rainfall occur consecutively, although it is possible that years of

low run-off may occur oftener if the rainfall is so distributed to produce that result.

GROUND WATER.

The elevation and amount of ground water stored on an area does seem to affect the dry-weather flow to a marked degree, it being noted that streams from an area largely of open, porous soils give a larger dry-weather flow than those from areas having soils of a clayey, impervious nature.

FORESTATION.

The amount of forestation on an area is also believed to affect the run-off to some extent, especially the minimum rate, although a wide difference of opinion seems to exist as to the extent of this influence. Mr. Rafter says that the presence or absence of dense forests on catchment areas in New York state may make a difference of as much as 5 or 6 inches in the annual run-off from the entire area.

He also thinks,

"that the removal of forests decreases stream flow by allowing freer circulation of air and by causing higher temperature and lower humidity in summer, and so producing greater evaporation from water surfaces as well as from the ground."

"That the removal of forests renders stream flow less equal throughout the year, and so causes floods and periods of dryness in rivers, seems to be beyond reasonable question, for the forest litter and root masses serve as storage reservoirs — tendency to equalize the flow of streams."

Mr. Vermeule states,

"that there is nothing in our observations of stream flow which indicates that forests or other vegetation have any marked effect upon the *total annual evaporation* from a watershed, but that upon deforested areas we may show that moderately heavy floods are now prevalent, and periods of very low flow more frequent and longer extended."

"The effect of forests in holding and preserving the soil upon slopes is very well known, and besides this they create a mass of humus and absorbent matter upon the surface which has an effect upon stream flow, and the general evils resulting from deforestation are a matter of careful observation and record, so that too much stress cannot be laid upon the desirability of preserving a proper area of forests."

"So far as they affect the flow of streams we consider their

most valuable service to be that they *equalize the flow*, which they do to a marked extent."

SIZE OF AREA.

The size of the catchment area has also been held by some to affect the run-off and its distribution. The table already given from Mr. Vermeule's report would seem to support that view.

In order to compare the run-off at different seasons from New England areas, varying widely in size, but similar in other characteristics, the exhibit on the following pages was prepared (Table No. 3).

The areas considered are the Merrimac River area, containing 4 451 square miles; Nashua River, 119 square miles; Sudbury River, 75.2 square miles; Stony Brook (Waltham), 22 square miles; and several small brook areas in Fall River, containing from 5.45 to less than one square mile area. The years selected were 1899, 1900, and 1901, because the observations on the Fall River brooks were taken on these years only. These figures are taken from the excellent report made by Mr. Arthur T. Safford, consulting engineer to the Reservoir Commission of Fall River, in 1902. The year 1899 had a little less than the average rainfall, while 1900 and 1901 had a little more than the average.

In comparing the average daily run-off from the areas given for each of the three years, it will be seen that the rate is remarkably uniform considering the different sources from which the records were obtained, the total average run off from the seven areas for the three years being 1 063 000 gallons daily per square mile of area.

The average run-off for the wet periods, December to May inclusive, on the other hand, show a tendency to increase with the decrease in catchment area. The average run-off for the dry periods, June to August inclusive, show a marked decrease with the decrease in the size of catchment area — and the same in some degree may be said of the following period, September to November inclusive.

Another interesting fact to be noted from an inspection of the figures is, that while the average yearly flow from the Sudbury River area is about the same as the others shown, the run-off during the dry period is *extremely small*, much smaller even than that from the smallest area.

TABLE No. 3.
EXHIBIT SHOWING RUN-OFF FROM CATCHMENT AREAS OF VARYING SIZES IN NEW ENGLAND.

	Merrimac River 4 451 sq. mi. Catchment. Gals. daily per square mile.	Nashua River 119 sq. mi. Catchment. 2.24 sq. water surface.		Sudbury River 75.2 sq. mi. Catchment. 6.54 sq. water surface.		Stony Brook, Waltham 22 sq. mi. Catchment. 5.4 sq. water surface.		FALL RIVER			Av. 3 Brooks 1.08, 0.63 & 0.47 sq. mi. Catchm't. Gals. d.p.s.m.
		Rainfall Inches.	Gals. d.p.s.m.	Rainfall Inches.	Gals. d.p.s.m.	Rainfall Inches.	Gals. d.p.s.m.	Rainfall Inches.	North Ponds 5.45 sq. mi. Catchment. Gals. d.p.s.m.	King Philip & Blossom Brook 2.14 sq. mi. Catch. Gals. d.p.s.m.	
1899											
January	1 140 000	2.93	2 092 000	4.18	2 288 000	4.43	2 121 400	5.62	2 659 600	2 921 200	2 214 400
February	761 000	5.12	1 090 000	4.91	1 381 000	4.83	1 273 500	3.84	2 201 100	2 470 200	1 891 000
March	1 735 000	6.75	2 776 000	7.01	4 205 000	8.78	3 969 800	6.19	4 291 300	4 770 000	4 116 400
April	3 839 000	1.94	3 376 000	1.90	2 521 000	1.49	2 427 100	2.17	1 483 400	1 570 000	1 307 200
May	1 383 000	1.53	862 000	1.45	511 000	1.06	388 400	1.81	1 556 100	716 500	426 500
June	433 100	5.51	561 000	2.51	66 000	3.10	124 200	3.86	160 400	238 800	102 800
July	360 300	3.81	354 000	3.22	10 000	3.03	332 900	2.78	140 300	248 900	62 000
August	302 800	3.20	236 000	1.43	—35 000	3.66	368 000	1.64	41 900	62 500	28 200
September	289 600	4.11	250 000	3.95	94 000	5.25	278 000	7.06	177 500	265 100	91 000
October	259 800	2.72	245 000	2.69	115 000	1.79	274 200	1.94	208 400	271 500	111 200
November	405 300	1.94	430 000	2.18	304 000	3.44	262 900	2.21	320 100	396 300	201 100
December	405 900	2.03	359 000	1.78	220 000	2.04	275 600	1.26	227 700	273 000	146 000
Total		41.40		37.21		42.90		40.39			
1900											
January	487 900	4.56	796 000	4.96	794 000	5.41	482 400	4.52	788 400	706 400	654 500
February	2 393 000	8.69	4 054 000	9.14	3 800 000	10.31	2 148 000	5.12	2 034 200	2 018 000	1 924 000
March	2 359 000	6.19	3 722 000	6.35	3 654 000	5.55	2 747 000	4.02	2 376 900	2 380 500	2 292 200
April	2 686 000	2.76	1 580 000	2.58	1 350 000	2.08	1 165 000	2.10	1 104 600	1 217 900	878 100
May	1 454 000	4.34	1 382 000	4.32	1 312 000	4.86	1 467 700	5.33	1 780 600	1 942 100	1 542 700
June	574 500	3.59	578 000	2.99	316 000	2.98	516 500	1.68	276 900	350 900	200 000
July	264 400	3.20	217 000	2.42	—18 000	2.66	274 200	2.92	93 900	148 600	50 600
August	272 400	3.18	197 000	2.22	—34 000	2.39	274 300	2.02	22 700	27 300	20 200
September	219 500	3.46	127 000	3.36	65 000	4.85	283 300	3.54	67 800	96 900	36 200
October	365 600	2.90	282 000	3.83	186 000	3.63	266 800	5.00	133 800	217 000	60 900
November	849 500	6.44	875 000	5.70	663 000	4.67	374 400	3.93	356 400	423 200	257 200
December	985 100	3.15	1 570 000	2.74	1 096 000	2.52	821 000	2.46	576 500	606 800	484 400
Total		52.46		50.65		51.91		2.64			

TABLE No. 3 — *Continued.*

	Merrimac River 44.51 sq. mi. Catchment. Gals. daily per square mile.	Nashua River 119 sq. mi. Catchment. 2.2% water surface.		Sudbury River 75.2 sq. mi. Catchment. 6.5% water surface.		Stony Brook, Waltham 22 sq. mi. Catchment. 5.4% water surface.		FALL RIVER.			
		Rainfall Inches.	Gals. d.p.s.m.	Rainfall Inches.	Gals. d.p.s.m.	Rainfall Inches.	Gals. d.p.s.m.	Rainfall Inches.	North Ponds 5.45 sq. mi. Catchment. Gals. d.p.s.m.	King Philip & Blossom Brook 2.14 sq mi.Catch. Gals. d.p.s.m.	Av. 3 Brooks 1.08, 0.63 & 0.47 sq. mi. Catchm't Gals. d.p.s.m.
1901											
January	491 200	1.75	519 000	1.82	437 000	1.42	260 000	2.22	597 600	613 300	528 900
February	356 300	1.13	356 000	1.52	300 000	1.17	200 000	0.95	310 400	353 500	273 000
March	1 384 000	5.82	2 718 000	6.57	2 755 000	6.71	1 441 200	6.54	2 504 600	2 728 300	2 327 600
April	3 779 000	9.64	4 986 000	8.60	4 204 000	6.68	3 367 300	8.39	4 179 300	4 557 600	3 937 200
May	2 267 000	7.02	2 729 000	7.23	2 954 000	7.58	2 845 100	8.05	3 566 700	4 263 100	3 074 600
June	1 092 000	1.51	985 000	1.38	753 000	7.13	744 300	1.69	1 158 100	1 353 100	969 300
July	419 800	5.06	477 000	5.71	306 000	5.44	151 700	3.18	246 700	313 300	181 700
August	645 900	4.58	512 000	4.57	424 000	4.67	286 600	2.46	97 400	156 100	61 000
September	386 100	3.10	320 000	3.30	305 000	4.01	294 700	2.51	25 700	43 000	14 100
October	599 600	3.70	617 000	2.82	412 000	2.68	255 800	3.17	213 400	304 800	86 300
November	436 900	2.43	517 000	2.90	474 000	2.78	334 200	2.18	163 200	218 600	81 800
December	1 417 000	9.36	3 234 000	2.69	2 695 000	7.38	1 423 700	8.64	1 145 800	1 352 500	1 174 400
Total		55.70		56.11		51.65		50.28			

TABLE No. 3 — *Concluded*.
SHOWING THE YEARLY AVERAGE RUN-OFF.

	Merrimac River 445½ sq. mi. Catchment. Gals. daily per square mile.	Nashua River 119 sq. mi. Catchment. 2.2½ water surface. Gals. d.p.s.m.	Sudbury River 75.2 sq. mi. Catchment. 6.5½ water surface. Gals. d.p.s.m.	Stony Brook, Waltham, 22 sq. mi. Catchment. 5.4½ water surface. Gals. d.p.s.m.	FALL RIVER		
					North Ponds 5.45 sq. mi. Catchment. Gals. d.p.s.m.	King Philip & Blossom Brook 2.44 sq mi. Catchment. Gals. d.p.s.m.	Av. 3 Brooks 1.08, 0.63 & 0.47 sq. mi. Catchm't. Gals. d.p.s.m.
1899	919 200	1 052 600	973 000	1 008 000	1 035 000	1 179 300	891 200
1900	1 076 100	1 281 700	1 082 000	901 700	794 800	838 500	700 000
1901	1 106 200	1 500 000	1 342 000	967 000	1 214 600	1 361 200	1 054 600
	1 063 000 (daily average flow).						

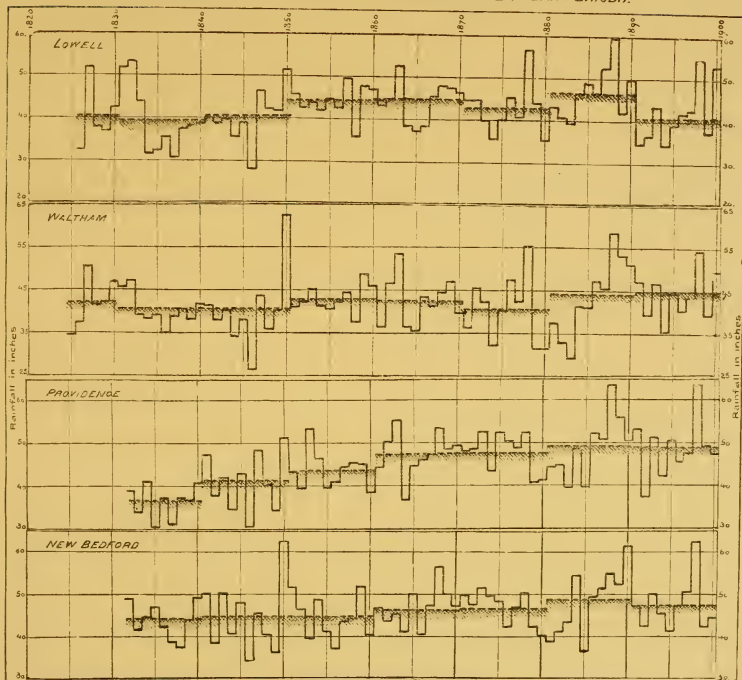
SHOWING THE AVERAGE RUN-OFF BY PERIODS.

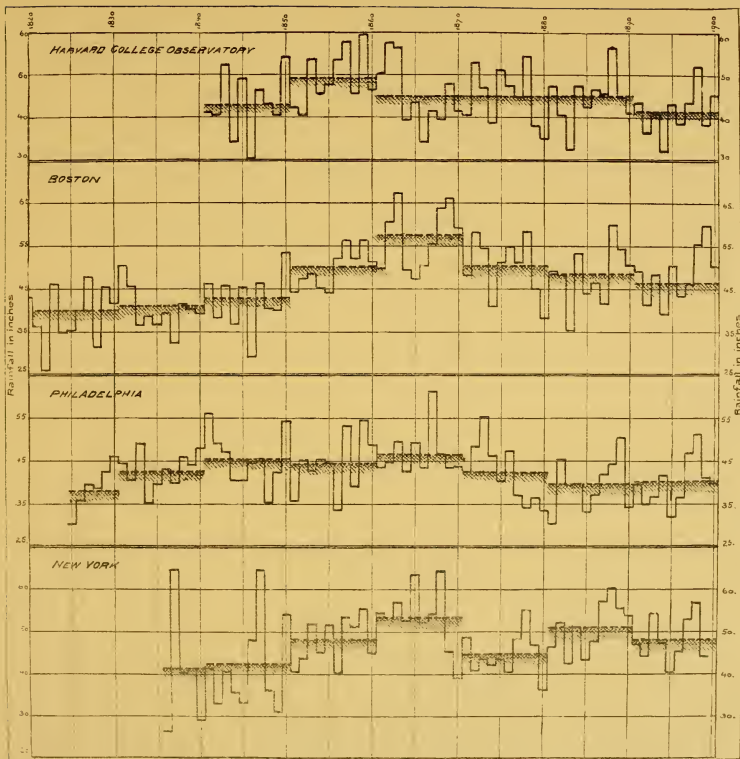
	Jan.-May, '99	June-Aug., '99	Sept.-Nov., '99	Dec., '99, } -May, '00	June-Aug., '00	Sept.-Nov., '00	Dec., '00, } -May, '01	June-Aug., '01	Sept.-Nov., '01
	1 771 600	2 039 200	383 700	308 300	1 998 000	330 700	428 000	651 300	494 700
	365 400	13 700	171 000	1 855 000	355 000	308 200	1 489 100	394 200	397 000
	2 137 000	2 053 000	275 000	1 380 900	355 000	308 200	1 489 100	394 200	397 000
	1 114 200	2 238 300	271 700	1 385 400	131 200	186 000	1 955 900	500 700	134 100
	183 400	2 489 600	310 970	1 422 900	175 600	245 700	2 187 100	607 500	188 800
	134 400			1 239 600	90 200	118 100	1 771 000	385 700	60 730

SHOWING THE AVERAGE RUN-OFF FOR DRIEST THREE MONTHS.

	1899	1900	1901
	284 000	244 000	244 000
	252 100	180 000	180 000
	414 200	436 300	436 300
		13 700	13 700
		4 300	4 300
		341 000	341 000
		220 400	220 400
		271 800	271 800
		231 000	231 000
		114 200	114 200
		61 500	61 500
		95 400	95 400
		183 400	183 400
		90 900	90 900
		139 200	139 200
		60 400	60 400
		35 600	35 600
		52 300	52 300

SHOWING ANNUAL RAINFALL AND AVERAGES BY TEN YEAR PERIODS.





This may be partly accounted for by the large percentage of water surface contained in the area in reservoirs, ponds, swamps, etc., but even after making a correction for that the amount is still much below the run-off from other areas for the same period.

It is plain that the Sudbury River is not a good dry-weather stream, and that estimates based on the flow of that stream as given in the reports would at least be conservative and safe for most areas in the vicinity.

This but illustrates the fact which can scarcely be too strongly emphasized in closing, — that most areas are to a certain extent a law unto themselves, and have certain peculiarities of their own, which should be carefully studied and compared in the light of the best data obtainable, if the best and most reliable results are to be secured.

DISCUSSION.

PROF. DWIGHT PORTER. Mr. Hastings has referred to the formula by Mr. Vermeule of New Jersey, by aid of which the evaporation from land surfaces can be computed. I have a friend here from California who tells me that in a case there with which he is familiar they applied that formula to the evaporation from land surfaces, with the result that the evaporation for the year was shown to be much more than the entire rainfall for the year, which seems to be an absurd result, and indicates, I think, the danger of putting too much confidence in a formula of this kind, especially when you apply it to a region distant from that for which it was framed.

MR. HASTINGS. I think Mr. Vermeule in his book expressly states that the formula is applicable primarily to New Jersey, but he thought it might be applicable to many other localities. I doubt, however, whether he would want to apply it to California or Arizona.

MR. RICHARD A. HALE. I have been very much interested in Mr. Hastings' paper, and I think there are a good many important facts in it. He has spoken of the different yield of large and small drainage areas, and I think that is very noticeable in the observations taken on rivers with drainage areas of different sizes. At Lawrence, on the Merrimac, which is one of the rivers

which Mr. Hastings refers to, we have a minimum yield of .3 of a cubic foot per second per square mile during the dry season; and on the Shawsheen and Spicket rivers, which are adjacent, with areas of only about 70 and 84 square miles respectively, the minimum yield is about one-third of that, or about 0.1 cubic foot per second per square mile. We are having some daily observations made on these rivers, and the difference is particularly noticeable on small streams. During the year 1900, which was an exceedingly dry period, the minimum weekly flow of the Merrimac was .3 of a cubic foot per second per square mile (average for 24 hours), and in 1883, which was one of the driest years known for a long period, the flow was .25 of a cubic foot per second per square mile, which is as low a discharge as the large river has ever given. At the same time the small streams were practically dried up, showing that the Merrimac was drawing from the underground sources of supply.

In regard to the tables to which Mr. Hastings has referred, the yields might show a little change if they were arranged according to the order of dryness in each year. On the Merrimac the period from June to August is not always the driest period, but September and October are often the driest months of the year, and November is likely to be one of the wet months. In making comparisons we find it convenient to take a series of years, arranging the months from the driest to the wettest, and taking the averages of the driest months in each year, the second driest, and so on. But Mr. Hastings' arrangements afford the means of very interesting comparisons, and are certainly of great value.

It would be of great interest if more records could be kept in regard to the flow of small streams, and, where there are pumping stations and dams, records of what is pumped and what runs to waste would indicate the yield and the run-off of the streams. It is a matter which can be arranged for very readily where there are dams and overflows. Records of this sort are very valuable, and Mr. Newell, the Chief Engineer of the Hydrographic Survey, is making a very important compilation of such records. The data are of great benefit in increasing our general knowledge of the flow of streams.

METER RATES.

BY FREEMAN C. COFFIN, CIVIL AND HYDRAULIC ENGINEER,
BOSTON, MASS.

[Read January 13, 1904.]

Engineers and water-works officials are, I think, becoming more and more impressed with the belief that the general use of meters is desirable, and that the method of collecting revenue by means of fixture rates, which is now almost universal, will some time become obsolete and water meters become as universal as gas meters.

There is at present some popular prejudice against their use, people believing that with them they will be restricted in the use of water, or that their bills will be larger.

I do not propose to offer any arguments for the use of meters at this time. We have had some such, notably an excellent one in the recent paper of Mr. J. Herbert Shedd. The results in every city or town which has adopted meters to a considerable extent are substantial arguments for their use.

What I wish to do now is to point out the fact that, viewed as a scientific method of assessing water rates, the meter system, in so far as a basis of rates is concerned, is in almost as chaotic a state as the fixture rate system itself. Several years ago in a paper which the present writer read before this Association, he made the following remarks:

“If the rates in any system are not satisfactory, being either too high or too low, the problem of their adjustment to the requirements of expenditure is one of which it may not be too much to say that no solution has been advanced that considers the conditions of the problem.

“The same may be said of fixing rates for new works. The only method that the writer is cognizant of is that of comparison, and comparison of rates only and not of conditions as well. To collect the schedules of several systems and construct rates from these without regard to such factors as cost of construction per capita, consumption of water per capita, cost of water per million

or thousand gallons, etc., is not a rational method, and gives no assurance that the revenue will be approximately equal to the requirements; yet many if not all rates are fixed in this way.

“There can hardly be a theory advanced for the adjustment of fixture rates. It is possible that with the sale of water by measurement, rates could be devised that would bear some relation to the revenue required. This would, however, be difficult and uncertain until more data upon the subject are available.”

These remarks are as true to-day as they were then. When meters are to be introduced to a large extent in any water-works system, some system of charges must be devised.

The object should be to so arrange these charges as to secure just about enough revenue each year to meet all of the expenses of maintenance that are not met from sources other than water consumers, so that the minimum charge shall allow the class paying the lowest rate under meter regulations an abundance of water for reasonable use, but none for waste; also arranged so that people with large houses and a great number of fixtures cannot by exceedingly close calculation escape with paying the equivalent of one faucet rate, and above all to encourage the prevention of leaking fixtures and the accompanying excessive per capita consumption of water.

If water-works officials wish to arrange suitable meter rates, what have they to guide them, where can they look for information? If they ask their consulting engineer for advice, what can he answer them? where can he go for data on the following points?

Namely: How much shall be the charge per thousand gallons? What shall be the minimum annual charge? To what class of service shall it apply? How much water shall be allowed for the minimum rate? If the minimum rate is adjusted for the single-faucet class of consumers, will the revenue from large houses with many fixtures be commensurate with the comfort and luxury of the service furnished? If not, how can this case be met? How can meter rates be arranged in a place with a large summer and small permanent population?

The above are all practical questions. Who can answer them with any degree of confidence?

The rates must be arranged, however, so that on the one hand

the revenue shall be sufficient, and on the other that the charges to careful consumers shall be equitable and not more burdensome than the old fixture charges.

There must be an accumulation of valuable data upon all or many of these points in the water offices of those municipalities which have a considerable proportion of their services metered, but no one engineer or no one board of water commissioners can collect and digest them.

In view of the foregoing, and in order to bring this matter up for discussion, I make the following motion. It is not pressed for immediate action, but it is hoped that before long this Association, following its past record in undertaking the consideration of problems that call for co-operative action, will carry out the suggestion in some form.

Moved: That a committee of this Association be appointed to consider the question of meter rates for water service, collect and digest information, and submit to the Association a schedule or schedules designed to meet various conditions of a metered service, or a basis upon which such schedules can be arranged; that this committee consist of five members; that the committee be authorized to expend a sum not exceeding fifty dollars in printing, postage, and other necessary expenses involved in the collection of data.

THAWING FROZEN SERVICE BOXES, PIPES, ETC.

TOPICAL DISCUSSION.

[January 13, 1904.]

PRES. EDWIN C. BROOKS. I may mention one little thing in my recent experience. It is very simple, perhaps trivial, and it may be of no importance; possibly many people are doing the same thing every day; but during this cold spell, when shutting off water from houses was a constant occupation, we found that a good many covers of standpipes or service boxes were frozen down, and the men had to run into the neighboring houses after hot water to thaw them out so they could get the covers off. It happened to occur to one man that a little benzine, poured on to the top of the cover and lighted, would be a good thing. It was tried and the consequence is that we don't have to run after hot water any more. A bottle of benzine holding a quart will be sufficient for perhaps fifty service-box covers. It does the work perfectly, and it isn't necessary to annoy any householder, — and you know that oftentimes we may have to go into three or four houses before we can get a pail of hot water. Now, as I say, that is a little thing, something which everybody ought to have thought of, but how many have thought of it?

MR. JOSEPH E. BEALS. Will kerosene do instead of benzine?

THE PRESIDENT. Kerosene does not light readily, but a little naphtha does very nicely. You know that the ordinary Morgan box has a little receptacle around the screw, and by the time the benzine has burned out the cover is hot and the thing comes up without any trouble. And even the old-fashioned boxes where the cap slips down over, which are particularly annoying to get up in brickwork, yield to the treatment very readily.

MR. J. C. HAMMOND, JR. Several years ago I read in one of the water-works journals about the use of lime for thawing. We had a 3-inch branch running into a court with only one or two service pipes on it, and it froze,—the branch and the whole business. We went to work and dug down, opening a hole perhaps two feet deep, when I happened to think of what I had read.

We were close to a lumber yard and I got a barrel of lime and dumped it into the hole and threw some water on it; and the next morning when we came there the pipe was thawed out and the ground was all softened.

Mr. Hardy, superintendent at Holyoke, can tell you how he thaws out a frozen pipe without digging.

MR. J. D. HARDY. We have a boiler on wheels which we use for thawing out pipes. We can draw it around the city anywhere with one horse, and we connect a hose pipe to the boiler, and on the end of the hose we have, say, a $\frac{3}{4}$ -inch pipe about six feet long, with handles on it, and we let steam on under from 50 to 60 pounds pressure, start it down into the ground, and it will go as readily as you can imagine. It will go right down. We put it down about where we think the pipe is frozen, and let it "cook" there, as we call it, that is, let the steam be on for a few minutes; and if that doesn't thaw it out we move along on the line. We find it a very excellent way of thawing out pipes and very handy for many purposes.

MR. CHARLES K. WALKER. I have been thinking of this thing and have been trying to find somebody who would make me a small gasoline boiler which two men could put into a sleigh and carry around to thaw out hydrants and service pipes, but I haven't been able to get anybody yet. Such a machine, weighing, say, from 200 to 250 pounds, would be very handy. I have a boiler, but it takes two horses to pull it, and it seems to me that a machine might be made which could be run with kerosene or gasoline or something of the kind, and would be light and easily handled, and which would do all the business. Now if the gentleman from Holyoke has got something which weighs more than 250 pounds that is one thing, but if he has got a light one I would like to talk with him.

MR. HARDY. Ours is very easily handled; a horse will take it around anywhere without any trouble. It is light enough so that one horse can pull it.

MR. WALKER. Of course you can't go into a cellar with that and thaw out into the street. It is going to freeze eight or ten feet deep in Manchester this winter if it keeps on, and the service pipes are likely to get caught.

MR. HARDY. We have another machine that we use in going

into cellars, with a block-tin pipe which we can run out if we choose. But when we do that the service is liable to freeze up again, unless the water is kept running continually. But with this boiler, when you once thaw out a pipe or a hydrant it is done for the winter. There is no probability of the frost going down again, — that is, we have never found it to happen. It is a very convenient thing to put down by the side of a hydrant; it can be done very quickly, and it doesn't injure the hydrant. I should like to have any of you gentlemen come up to Holyoke and see it.

MR. FRANK L. FULLER. Do you make a hole with a bar for your steam nozzle?

MR. HARDY. No, it goes right down itself; you don't have to make any hole.

MR. FULLER. The pressure of the steam will make a hole?

MR. HARDY. It will make a hole, clear everything right out in front of it,— any small stone or anything of that kind. It will go down in the time I have been talking with you. At least it does at Holyoke.

THE PRESIDENT. With regard to the use of lime, a few years ago I happened to be up in Waltham and I noticed they were putting in a siding on an electric road there. There must have been nearly two feet of frost in the ground. It was a macadamized street, and I saw them scatter along on the line for their digging several barrels of lime, which they then covered up with a load of manure and wet down. The next day the ground was in perfect shape for digging, without any frost, and the siding was put in and everything finished up in good shape.

The plumbers, who, as you all know, have had a particularly good harvest lately, have taken up the idea of a small tubular boiler about 12 inches high and 10 or 12 inches in diameter, with three or four 1-inch tubes put through from head to head, and a little crude safety-valve and stopcock on the top of it. That is set on a plumber's furnace. They go into a cellar with it and in a very few minutes will have steam enough so they can thaw out a pipe very rapidly. They have a $\frac{3}{4}$ - or $\frac{1}{2}$ -inch rubber hose with a piece of block-tin pipe on the end of it, and it is very effective indeed. I think possibly that might be elaborated so as to make a very convenient tool for water-works people to use. I think a combination might be made with some of the larger

burners that they have for melting, and possibly they could use kerosene in place of naphtha if the naphtha was thought to be too dangerous.

MR. GEORGE E. WINSLOW. I will tell a little experience I had quite a number of years ago with services. I wanted a boiler so that I could get steam or hot water to thaw out services, but I didn't have the privilege of getting it, and so I was forced to use hot water when I could find any. But in some cases it was rather inconvenient to get hot water, and after I had this experience which I am about to relate I didn't bother any more to try to get it. I had a service which ran down a lane and turned at a right angle into a house, and that was frozen for its whole length. The distance from the angle to the street main was about eighty feet. I had to dig down to get at the pipe, and then I used a block-tin pipe, the same as you all do, and used cold water with a Johnson pump. I think the friction of the water against the ice wore it away, but at any rate I had no trouble in freeing the pipe with cold water, and I never bothered to get hot water after that.

THE PRESIDENT. I should think, Brother Winslow, that with the temperature down in the neighborhood of zero the cold water would become ice in the hole in which you were working before you had gone along a great way.

MR. S. A. AGNEW. The great trouble I have always found in thawing out a service pipe in that way has been that it would freeze up immediately afterwards. Mr. Hardy's method seems to be the best in that it warms the ground down under the surface and the pipe doesn't freeze again. But where a pipe is thawed out one day and we have a cold night following, the pipe will freeze up again unless the water is allowed to run. That is the great trouble in thawing the pipe out in the ordinary way. By Mr. Hardy's method the ground is warmed, and the probability is that the pipe will not freeze again during the winter unless there is another unusually severe cold spell.

MR. LEWIS M. BANCROFT. Mr. President, I have a small boiler which I think perhaps will answer Mr. Walker's purpose; or rather, one like it, for I don't want to give him mine. It is about a foot in diameter and about three feet high, an upright boiler. It only has one tube through the center. I place it over

a charcoal fire, have the fire pot of the same size, and I can get up 25 or 30 pounds of steam, and we use it through a block-tin pipe.

MR. ROBERT S. WESTON. There is a boiler made for chemical laboratories in sizes varying from about 100 to 300 pounds in weight. It has one tube and is heated either by a charcoal fire or a gas burner, and I should think it would answer for this purpose very well.

MR. WALKER. I want one with more than one tube. I want something which will make steam faster than any one-tube affair. I think Mr. Baneroft is all right, and if his boiler had three or four tubes I think I would take it. I have tried to have some of the boiler folks get up something for me, but they don't seem to know how to do it. I have a boiler which I like first rate, but it takes a couple of horses to pull it around. It is big enough to thaw out a whole city in a little while. It is 10 horse-power and will do quite a lot of business. But I thought there might be something which we could take around in a sleigh, which would weigh 200 or 250 pounds, a regular boiler with five or six tubes. That is my idea of the thing, and I would like to have the President tell me before I go home what I had better do.

THE PRESIDENT. I think you had better get an automobile boiler, and I wouldn't use charcoal or coal at all, but I would have a good efficient kerosene burner, or two or three of them, if necessary.

MR. WALKER. Where can I get such a thing as that?

THE PRESIDENT. I think you ought to consult the advertising pages of the JOURNAL. (Laughter.)

MR. WALKER. That is pretty good; I like that idea first rate.

THE PRESIDENT. I might volunteer the information that the Roberts Boiler Works in Cambridgeport are building automobile boilers all the time.

MR. WALKER. I am afraid of automobiles. (Laughter.) I don't like the sound of that word. However, if I could have the same kind of a boiler under another name it might do. (Laughter.)

MR. SULLIVAN. The boiler that Mr. Hardy speaks of is about two feet in diameter and about four feet and a half high. It is on wheels and he can take it anywhere he wants to and can use it for a great many different things when occasions arise. One

horse can haul it all right, and I think it is a good thing to have on any works.

MR. GEORGE A. STACY. As near as I can make out, what Mr. Walker wants, in the first place, is a boiler that will act quickly, and it seems to me that an automobile boiler is a good thing in that respect, for it is a quick steamer. One trouble about it, however, is that you have got to keep pumping water into it if it is generating steam rapidly, for if you don't do that you will burn it out. My idea is to have a drum above the boiler and connected with the top and bottom of it, and then by careful management you would never run the boiler dry. It would be practically a double boiler; you could take your steam out of the top connection, and you might have four good burners. I should prefer kerosene burners. You could put that into a sleigh, and two men could handle it. That is something I have been thinking of and trying to get up, and I don't know of anything, so far as the boiler is concerned, which for safety and efficiency and quick action will beat an automobile boiler, and that can be readily obtained. Now, if you can have your receiver or your drum to insure that you are going to have water in the boiler under ordinary conditions, so that you can trust a man with it, I don't see why you can't light your fire and put it in your pump and have everything all ready when you get to the place where you want to use it. Then if you want to take it down into a cellar you can do so, or if you want to run up by the side of a hydrant you can do that, and by the time you have got there you have steam enough and water enough to do the work, and when you get through you can put out the fire. Of course it is necessary to have some sort of a shield so that when you go out on a cold, windy day you can keep your fire burning, and if you do that I don't see any difficulty about getting up steam and having something handy to work with. Of course if you have got to do some more extensive work and thaw out the ground you need an eight or ten horse-power boiler; but for something to use on the spur of the moment, in fifteen or twenty minutes, something which you can put into your team and light the fire and be all ready to go to work with by the time you arrive at the place, I don't know of anything better than an automobile boiler. It is perfectly safe if you have a pop safety-valve on it. One of these boilers will stand 400 pounds pressure

and you don't want more than a sixteenth part of that in order to do your work. Put your pop in so it will blow, and you are all right. I think there would be no trouble about a man handling it.

THE PRESIDENT. It would seem to me as though the drum Mr. Stacy speaks of would be rather a superfluity. I think the ordinary automobile boiler will hold water enough so that it will be perfectly safe from burning for half an hour.

MR. STACY. If you were going to use it, Mr. President, I should say it would be perfectly safe at any time, but I am providing so that men can use it who are not much acquainted with steam engineering.

THE PRESIDENT. If you have your drum and your bottom boiler filled with water it is true that you have more water, but it is also true that you will have to wait longer to get up steam; and your man is relying on having so much more water and is consequently going to presume that it will last so much longer; so I think the danger would be equally as great in one case as the other. I think a little gray matter is necessary to make the thing work, anyway.

MR. STACY. That may be true, but it seemed to me that a drum would be of value as a preventive against carelessness. It wouldn't be necessary for me, if I was going to handle it, to have a drum, but I shouldn't want to send an ordinary man out with it without one. If I did, I should expect to have to calk the tubes when he came back with it.

FREEZING OF HOUSE METERS.

TOPICAL DISCUSSION.

[February 10, 1904.]

PRES. EDWIN C. BROOKS. I should like to call your attention, gentlemen, to the trouble which some of us have had from the freezing of meters during this cold weather. I had hoped that Mr. Perkins, of Watertown, could remain long enough to relate to you the experience which he has had during this cold spell, but he was obliged to leave. Before going, however, he told me that they had not had a single meter freeze in their outside meter boxes; and, considering the fact that those meters are set so near the surface in earthen pipes, that seemed to me very remarkable. He told me that all the trouble he has had has been with meters in houses; and I may say that that has also been our experience in Cambridge. Now I think we have all got to consider seriously the question of setting meters outside. I find that houses are sometimes vacated where meters are set, the families go away and no notice is given, and the first thing we know somebody throws a snowball through a cellar window which unfortunately happens to be located right over the meter, and the meter freezes up.

I should like to hear the experience of some of the other members in regard to this very important question.

MR. E. W. KENT.* I have no meters set outside in earthenware pipes; mine are all inside. I have about 2 200 meters, and up to two weeks ago Saturday night we had removed 101 that were frozen.

MR. HORACE G. HOLDEN.† All our services run into the houses below the foundations, usually a foot below the cellar bottom. We set our meters at this depth in a box, and they are covered up. We have somewhere about 600 meters, and I think there haven't been over half a dozen, or about 1 per. cent. of the meters, that have been frozen; and all those that have been frozen have been where somebody has removed the covers. What we use for a box is made out of old cement lined pipe, about 12 or 15 inches

* Superintendent of Water Works, Woonsocket, R. I.

† Superintendent of Water Works, Nashua, N. H.

long, with a wooden cover. This we set just below the cellar bottom, right over the meter. Where there is any danger of its freezing we cover it up with bagging, because we own all the meters ourselves; the occupant or householder never owns the meter; they are all owned by the company.

MR. ROBERT J. THOMAS.* Out of 7 200 meters we have had about 300 frozen this winter. They were all meters which were set in cellars.

THE PRESIDENT. I should like to hear from Mr. King.

MR. GEORGE A. KING.† Most of our meters are set in cellars.

THE PRESIDENT. Have many of them been frozen?

MR. KING. Yes; I couldn't tell the number though.

THE PRESIDENT. What has Mr. Chace got to say?

MR. GEORGE F. CHACE. Nothing uncommon, Mr. President. Like other people, I have had some frozen meters.

THE PRESIDENT. Can Mr. Robertson tell us anything about Fall River?

MR. W. W. ROBERTSON. I should say our experience has been similar to that of Mr. Thomas. We have about the same number of meters, 7 200, and we have had about 300 frozen, according to my best recollection, although it may be a few less or a few more.

THE PRESIDENT. We should like to hear from Mr. Martin, of Springfield. I suppose it has been pretty cold out there.

MR. A. E. MARTIN. We have had some cold weather, Mr. President, and I think out of about 3 500 meters we have had 60 frozen, all of them in cellars.

MR. FRANK L. FULLER. We have 911 meters in Wellesley, and 47 of them have frozen. So far as I know they were all in cellars.

MR. LEWIS M. BANCROFT. We have about 1 050 in Reading. About 75 of those are in boxes in the streets. We have had no trouble with meters in those boxes, but we have had 57 freeze in cellars.

MR. M. F. COLLINS.‡ We have had about 150 meters frozen this winter, all in cellars; no outside meter has frozen. In all, we have 5 603 meters.

* Superintendent of Water Works, Lowell, Mass.

† Superintendent of Water Works, Taunton, Mass.

‡ Superintendent of Water Works, Lawrence, Mass.

NOTES ON THE CONSTRUCTION OF A STORAGE RESERVOIR.

BY W. H. RICHARDS, ENGINEER, NEW LONDON, CONN.

[*Read December 9, 1903.*]

In the following paper no effort is made to completely describe the whole work, but only such portions of the construction as are somewhat unusual.

Owing to the threatened shortage of supply occasioned by the scanty rainfall of the fall and winter of 1900-1901, it became necessary to increase the supply of water for the city of New London, Conn., by the construction of an additional storage reservoir. Work was begun in August, 1901, and the reservoir was completed in the spring of 1903.

As constructed, the reservoir has a drainage area of 2.7 square miles, covers an area of 46.5 acres, and has a capacity of 170 000-000 gallons, it being so arranged that any surplus can be stored in the main storage reservoir at a lower level.

The reservoir, Plate I, is situated in the valley of a large brook surrounded by heavily wooded hills, the immediate banks of the basin being gravel and sand interspersed with granite boulders. The sides of the basin were thoroughly grubbed and all soil removed down to clean gravel, but the bottom of the basin being composed of mud from 4 to 6 feet deep, it was covered with sand to a thickness of about 1 foot, after removing all stumps and projecting roots. As the water stands about 20 feet deep over this area and in no place comes in immediate contact with the muck or decayed vegetable matter, it is difficult to see how any considerable deterioration of the water can take place. The writer is aware that it is usual to expend large sums of money in removing the last vestige of decomposed vegetation, but, inasmuch as most large reservoir bottoms will be covered with such a deposit in a few years, and as on a bottom covered with sand the water does not come in direct contact with the decomposed vegetation or muck, and contamination by particles in suspen-

sion is thereby avoided, may it not be that the capacity of the muck to contaminate by solution has practically ceased and that large expenditures for its removal are unwarranted?

At the upper end of the basin a shallow arm was cut off from

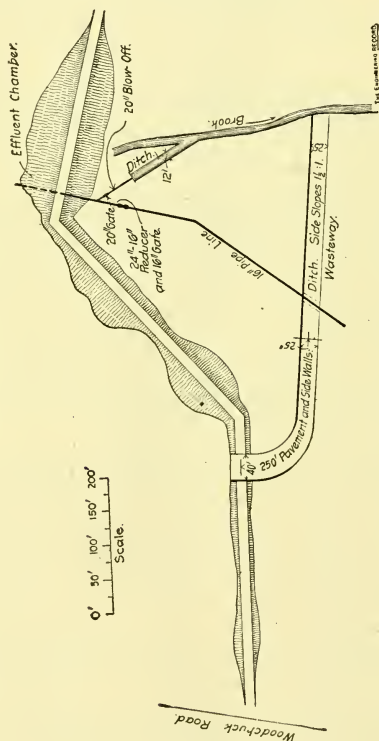
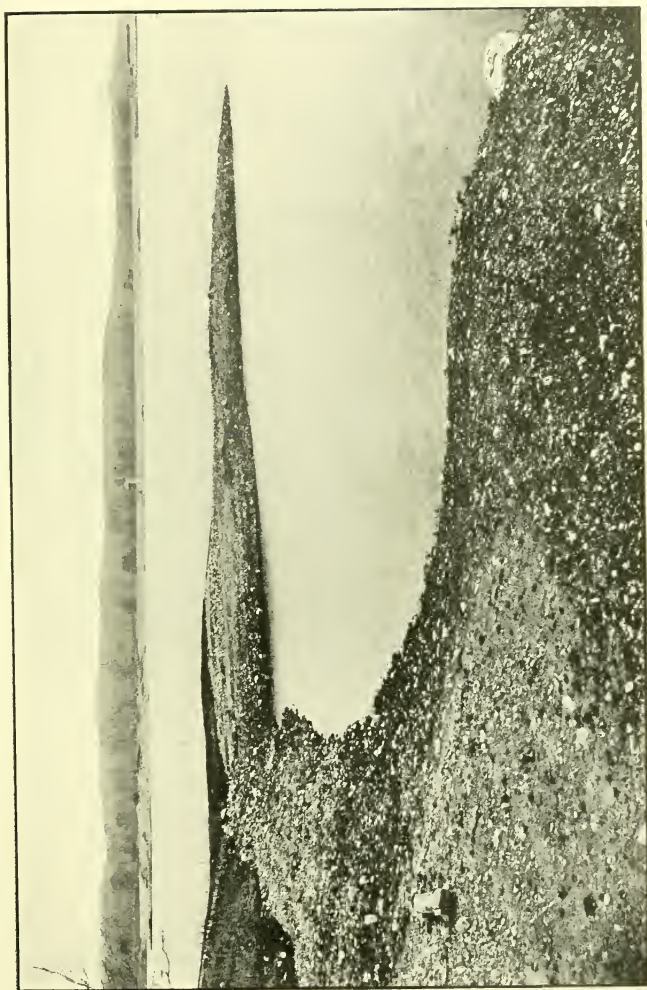


FIG. 1. PLAN OF MAIN PART OF DAM.

the main lake by a so-called filter dam. Above this dam no effort was made to grub or cover the surface, only stumps and roots being cut off close to the ground. The filter dam consists simply of a bank of gravel about 400 feet long, 20 feet high, and 10 feet wide



BARNS RESERVOIR, LOOKING SOUTHEAST.

on top. The water behind this bank is supposed to filter through it when the reservoir is drawn down.

In this connection it may be interesting to note that a similar construction in the lower reservoir has been in use about thirty years, with excellent results. An analysis made in 1887 showed a great diminution in color and in organic and volatile matter after passing through the dam.

The main dam consists of an earth and gravel embankment with concrete core wall about 1 200 feet long, the embankment varying in height from 10 to 25 feet above the natural surface. In locating this dam advantage was taken of a series of low hills, making the plan somewhat irregular but effecting a great saving in embankment (Fig. 1). Gravel and sand of various degrees of firmness, going to an unknown depth, underlie the entire site of the dam.

The concrete core wall was located close to the inner slope of the dam, the greatest care being taken to make it impervious; and as no dependence was placed on it to resist strains or add weight to the dam, it was made but 3 feet thick up to within 18 feet of the top, where it begins to batter, and at the top is $1\frac{1}{2}$ feet thick. This location gave room for the largest cross-section and consequent weight of embankment below the core wall, where needed. Views of the dam under construction are given in Plate II.

The concrete was formed of 1 part Portland cement and 9 parts of gravel and sand used as taken from the pit. This material from the pit, which was located in close proximity to the dam, was carefully examined at frequent intervals and the material kept as near the proportion of 3 sand, 2 fine gravel, and 4 stone not larger than $2\frac{1}{2}$ inches, as possible. The concrete was mixed very wet, $1\frac{1}{2}$ to 2 parts of water being used to 10 parts of stock, and was built between forms, the inner surface being plastered and washed after the removal of the forms. It was found that mixing the concrete wet vastly increased its density or lack of porosity, as when thrown between the forms the water rose to the top and ran off or evaporated. The concrete was built up in layers of about 2 to 3 feet, a triangular wooden block being placed in the center of the top of each layer to form a groove to dovetail with the next layer. The embankment on the outside of the wall was composed of sand and gravel, the finer material being placed next the core

wall and puddled, the coarse material outside this. This construction was adopted that the core wall might have as firm and

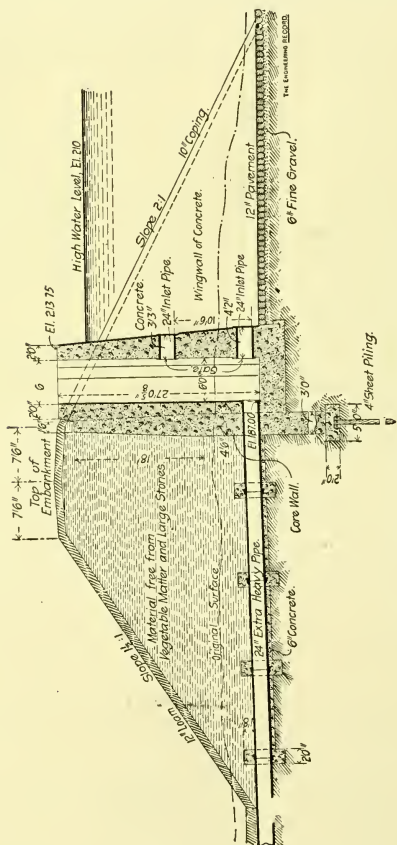


FIG. 2. SECTION THROUGH EFFLUENT CHAMBER.

uniform a backing as possible, and that in case of leakage the water might find its way through without destroying the embankment.

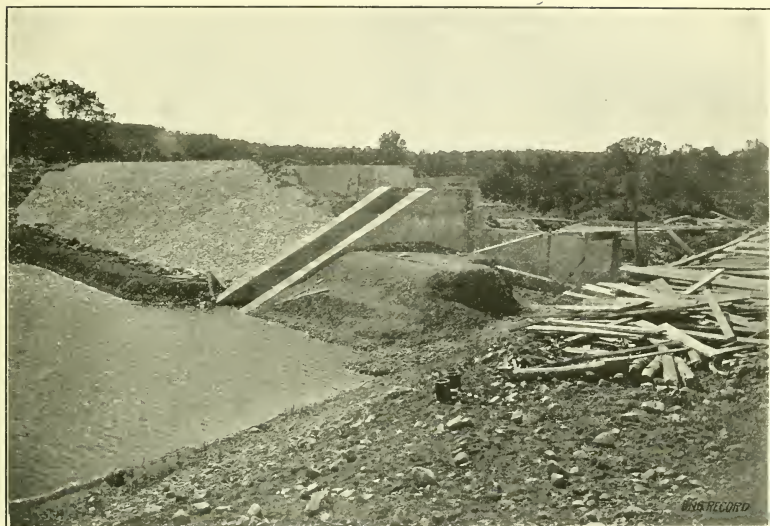


FIG. 1. PART OF UP-STREAM FACE OF DAM DURING CONSTRUCTION.

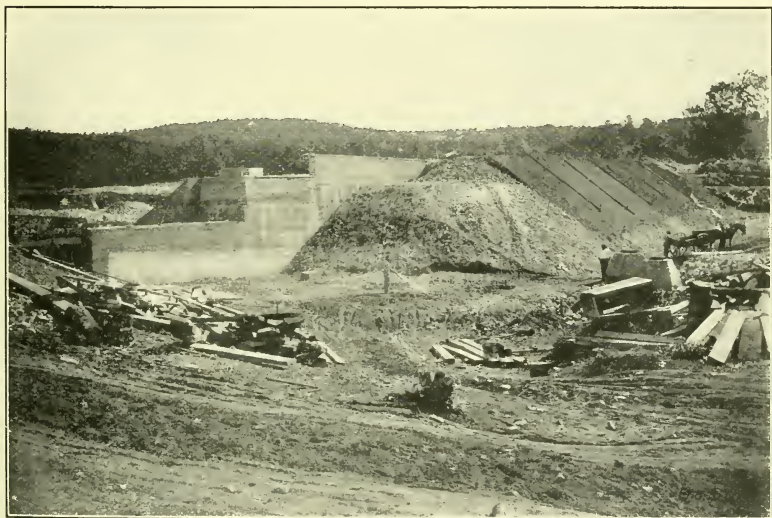


FIG. 2. PART OF DOWN-STREAM FACE DURING CONSTRUCTION.

The embankment in front of the wall was composed of loam thoroughly rolled, no clay being available. The inside slope was paved with 12-inch paving, the outside slope was finished with loam and seeded. The slopes were 2 to 1 inside and $1\frac{1}{2}$ to 1 outside.

In a portion of the core-wall trench a fine sand was encountered at a depth of 34 feet. Into this, 4-inch grooved and splined sheeting was driven to an additional depth of 25 feet, the core wall being built upon it. A portion of this sheeting was driven with a steam rock drill, having a light hammer substituted for the drill, the whole fastened to a frame and lowered into the trench, but as the light construction of the drill caused it to break frequently, an ordinary pile-driver giving very light blows was finally substituted; but the experience proved that with a sufficiently strong machine the rock drill has great advantages and economy over the ordinary pile-driver for driving sheet piles in a trench.

The gate-chamber, Fig. 2, was built of concrete similar to that of the core wall and surmounted by a stone gate-house. The spillway and wing walls were of granite. The spillway, Plate III, is 40 feet wide, or 15.8 feet for each square mile of watershed. The greatest observed depth of water on the overflow has been 6 inches. The water falls over the spillway with a perpendicular drop of 3 feet, and then runs down a paved slope of 12 in 100 into the brook below the dam.

Water is admitted into the chamber through two 24-inch sluice-gates and flows through a 16-inch and 20-inch main a distance of 3 miles to the main storage reservoir.

The cost of the work was greatly increased by the difficulties of transportation, as all material used, including 1 000 tons of pipe and nearly 4 000 barrels of cement, had to be carted over 10 miles of rough, hilly country.

The contract for the work was completed by the C. H. Eglee Co. in a very satisfactory manner, under the direction of R. W. Chaffee, Assistant Engineer.

DISCUSSION.

MR. FRANK L. FULLER. I should like to ask Mr. Richards to describe a little more in detail the driving of this sheet piling by the steam drill.

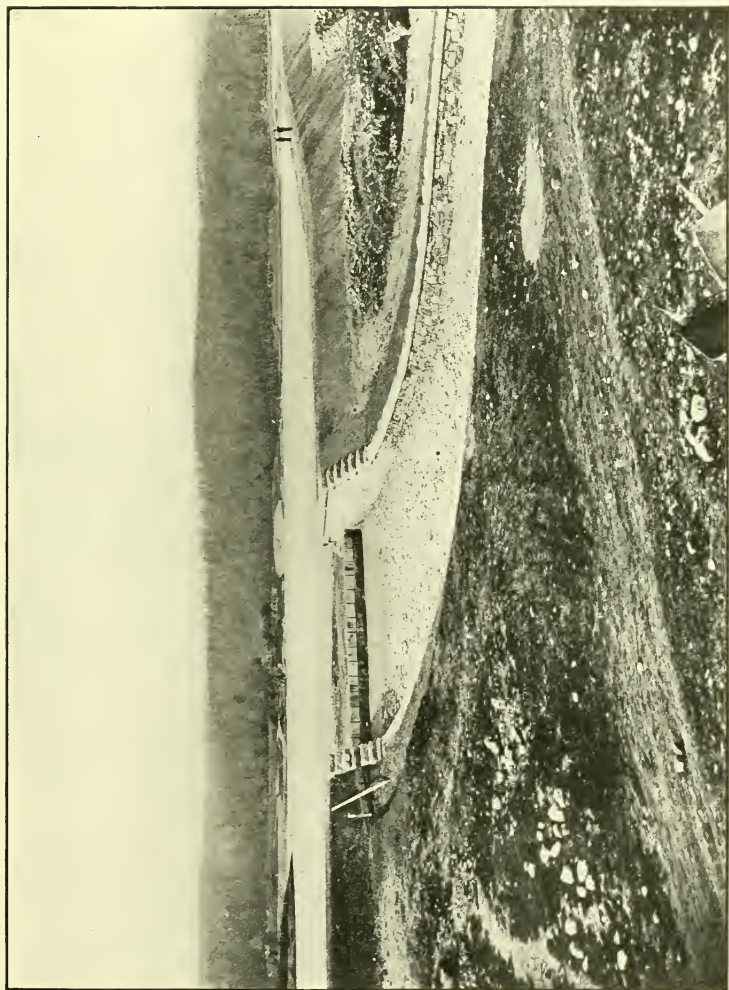
MR. RICHARDS. The sheet piling was 4 inches thick, usually about 8 inches wide, grooved and splined. It was driven between two waling pieces laid lengthwise of the trench, and as the trench was about 35 feet deep and in very fine sand at the bottom, it was, of course, rather difficult to use an ordinary pile-driver for the reason that its operation would shake the sides of the trench so they would be liable to cave in; and, furthermore, every brace would have to be moved when you moved your pile-driver along, and there were a good many of them in a 35-foot trench. So we tried a steam drill, first with a hammer we made ourselves, and afterwards with one which was made by the company. So long as the drill lasted we were very successful in driving the piles, — that is, the strokes of the hammer were so near together that the pile didn't have time to stick, or, in other words, the sand didn't have time to settle around it, but, having once started, the pile kept going. The drill, of course, was made for a different purpose, and it broke continually, so we finally had to give it up and use the ordinary pile-driver. I think a more strongly made drill would work very nicely, and I understand that they make one now especially for driving piles.

MR. FULLER. How heavy was the hammer you used?

MR. RICHARDS. My impression is it wasn't more than 10 or 15 pounds; it was very light.

A MEMBER. I believe Mr. Richards has some very interesting information with reference to an impulse wheel and rotary pump, and I should like to have him describe that to us in a few words, if he will.

MR. RICHARDS. I am not quite ready to describe the pumping station, as it is not finished yet, and I don't know exactly what it will do. I should prefer to wait until I have tried it. However, I can say that we were very peculiarly situated in having a water supply of such a quality that we couldn't use it for anything else but power, so we use it for power to pump to our high service. We have about 120 feet head, and with that head we use a jet impulse wheel, a Pelton wheel, in one case coupled directly to a rotary pump. We have another wheel which is coupled on to an ordinary triplex pump. So far it appears to work very nicely. It pumps against something like 60 pounds. When it is tested I shall be pleased to describe it.



BARNS RESERVOIR, LOOKING NORTH FROM SPILLWAY.

PROCEEDINGS.

DECEMBER MEETING.

HOTEL BRUNSWICK,

BOSTON, December 9, 1903.

President Charles K. Walker in the chair; Willard Kent, Secretary.

The following members and guests were in attendance:

MEMBERS.

S. A. Agnew, F. E. Appleton, E. W. Bailey, C. H. Baldwin, L. M. Bancroft, J. E. Beals, J. F. Bigelow, F. D. Berry, George Bowers, E. C. Brooks, G. A. P. Bucknam, E. W. Bush, L. Z. Carpenter, George Cassell, G. F. Chace, C. E. Chandler, R. C. P. Coggeshall, M. F. Collins, H. A. Cook, G. E. Crowell, A. W. Cuddeback, C. E. Davis, J. H. Flynn, F. L. Fuller, J. C. Gilbert, A. S. Glover, F. W. Gow, W. R. Groce, R. A. Hale, F. E. Hall, J. O. Hall, D. A. Harris, L. M. Hastings, V. C. Hastings, T. G. Hazard, Jr., D. A. Heffernan, H. G. Holden, J. L. Howard, A. F. Hill, W. E. Johnson, J. A. Jones, J. Wm. Kay, Willard Kent, G. A. King, G. A. Kimball, E. S. Larned, J. W. Locke, H. V. Macksey, N. A. McMillen, D. A. Makepeace, A. E. Martin, W. E. Maybury, F. E. Merrill, F. L. Northrop, E. M. Peck, Dwight Porter, J. B. Putnam, C. W. Sherman, J. W. Smith, G. H. Snell, H. W. Spooner, W. F. Sullivan, L. A. Taylor, R. J. Thomas, William H. Thomas, J. L. Tighe, D. N. Tower, W. H. Vaughn, C. K. Walker, W. J. Wetherbee, F. I. Winslow, G. E. Winslow. — 72.

ASSOCIATES.

Allis-Chalmers Co., by C. W. Houghton; Harold L. Bond & Co., by H. L. Bond; Builders Iron Foundry, by Frederick N. Connet; Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; Hersey Mfg. Co., by Albert S. Glover, James A. Tilden and Walter A. Hersey; Wm. V. Briggs, by William F. Woodman; Henry F. Jenks; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; H. Mueller Mfg. Co., by W. L. Dickel; National Meter Co., by Charles H. Baldwin and J. G. Lufkin; Neptune Meter Co., by W. H. Van Winkle and H. H. Kinsey; Perrin, Seamans & Co., by J. C. Campbell; Rensselaer Mfg. Co., by Fred S. Bates; Stilwell-Bierce and Smith-Vaile Co., by F. H. Hayes; Sumner & Goodwin Co., by H. A. Gorham; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by F. L. Northrop and A. S. Otis; Henry R. Worthington, by Samuel Harrison. — 25.

GUESTS.

L. C. McDermott, Superintendent Water Works, East Orange, N. J.; C. E. Bliss, C. F. Holmes, Attleboro, Mass.; Henry E. Perry, Superintendent Water Works, Dover, N. H.; H. L. Dunn, Hopedale, Mass.; W. B. Webber Brookline, Mass.; Charles A. Dean and W. H. Butler, Water Commissioners, Wakefield, Mass.; F. A. Allen, Cambridge, Mass.; J. E. Bunting, Boston; Walter Phillips, Weymouth, Mass.; Hon. Leonard B. Chandler, Mayor-elect of Somerville, Mass.; H. C. Hunter, Marlboro, Mass.; George Goodhue, Concord, N. H.; W. E. Lord, A. H. Plouff, Ipswich, Mass.; S. E. Kieffer, Cambridge, Mass., and George Z. Taft, Uxbridge, Mass. — 18.

(Names counted twice, — 3.)

The Secretary read the following names of applicants for membership, the applications having been approved by the Executive Committee:

For Resident Member.— Gorham Dana, Boston, Mass., Manager Underwriters' Bureau of New England; Henry E. Perry, Dover, N. H., Superintendent Dover Water Works.

For Non-Resident Member.— L. C. McDermott, East Orange, N. J., Superintendent East Orange Water Department; George A. Taber, Brooklyn, N. Y., Assistant to Chief Engineer, Department of Water Supply, New York City; Worthington Scranton, Assistant to President, Scranton Gas and Water Company.

On motion of Mr. Coggeshall the Secretary was directed to cast one ballot in favor of the applicants, which he did, and they were thereupon declared elected members of the Association.

MR. CHARLES W. SHERMAN: In view of the fact that so many of our members had such a pleasant trip this morning through the East Boston tunnel, I think a vote of thanks to the chief engineer and to the Boston Transit Commission will not be out of place, and I therefore move the adoption of the following vote:

Voted, That the thanks of the Association be given to Mr. Howard A. Carson, chief engineer, and through him to the Boston Transit Commission, for courtesies extended to us at our visit to the East Boston tunnel this forenoon.

Adopted.

MR. HENRY F. JENKS. I wish to say a few words, Mr. President, and if what I am about to say does not seem to be proper I had rather not be called to order until after I get through. Many of us who are now here remember our trip to Montreal last September, and we know that it must have required a great deal of

hard work and the exercise of good judgment to have worked out the details of the trip as nicely as it was done. Everything passed off very pleasantly, and for the Associates I can say that we had the best rooms for our exhibition that we have ever had; and I think we all agree that the trip was one of the best the Association has ever made. I therefore move a vote of thanks to our efficient committee, Mr. Merrill, Mr. Holden, and Mr. Kent, and to such others as assisted in making the occasion so pleasant for us.

THE PRESIDENT. It is not in order to pass a vote of thanks to members of the Association for anything they do for us. So, while they are certainly entitled to our thanks, and we can think so as much as we please, yet it will not be in order to put your motion, Mr. Jenks.

MR. JENKS. That is satisfactory to me.

The President then introduced Hon. L. B. Chandler, the newly elected mayor of Somerville, who made a brief response.

The first paper of the afternoon was by Mr. W. H. Richards, Engineer and Superintendent of Water Works, New London, Conn., entitled, "Notes on the Building of a Storage Reservoir."

Mr. L. M. Hastings, C. E., Cambridge, Mass., then presented a paper on "Rainfall and Run-Off from Catchment Areas," which was discussed by Professor Porter and Mr. R. A. Hale.

MR. W. R. GROCE. Some three years ago, Mr. President, I had a bill put into the Legislature providing that the matter of the collection of water rates be put on the same basis as the collection of taxes, that is, that the real estate be holden for the water rates, but the committee to which it was referred reported that it was not desirable to pass it. Now, I should like to have this Association take that matter up, and I move that a committee be appointed to consider the advisability of asking the Legislature to pass such a bill, so that we can collect the water rates from the owner of the real estate, just the same as the tax collector can collect the taxes.

MR. DEXTER BRACKETT. I should like to ask if it is the intention that this committee shall have authority to represent the Association before the Legislature.

THE PRESIDENT. I so understand it.

MR. C. F. KNOWLTON. I don't believe the Association wants to send a committee to the Legislature to tell the Legislature

that the Association desires certain legislation. If a committee is to be appointed I think the committee should report back to the Association and then we can discuss the matter here.

MR. GROCE. I will move, Mr. President, that the matter be referred to a committee of three for its consideration, the committee to report at the next meeting.

The motion was adopted and the President announced he would take time to appoint the committee.

Adjourned.

ANNUAL MEETING.

HOTEL BRUNSWICK,
BOSTON, January 13, 1904.

President Charles K. Walker in the chair.

The following members and guests were present:

MEMBERS.

S. A. Agnew, C. F. Allen, C. H. Baldwin, L. M. Bancroft, J. E. Beals, F. D. Berry, J. M. Birmingham, J. W. Blackmer, George Bowers, Dexter Brackett, E. C. Brooks, G. A. P. Bucknam, George Cassell, G. F. Chace, J. C. Chase, S. K. Clapp, F. C. Coffin, R. C. P. Coggeshall, M. F. Collins, W. R. Conard, F. W. Dean, H. P. Eddy, J. N. Ferguson, J. H. Flynn, F. F. Forbes, F. L. Fuller, Albert S. Glover, W. J. Goldthwait, F. E. Hall, J. O. Hall, J. C. Hammond, Jr., J. D. Hardy, G. H. Hart, L. M. Hastings, T. G. Hazard, Jr., D. A. Hefferman, H. G. Holden, E. W. Kent, Willard Kent, E. S. Larned, J. W. Locke, H. V. Macksey, N. A. McMillen, A. E. Martin, W. E. Maybury, F. E. Merrill, Leonard Metcalf, H. A. Miller, F. L. Northrop, W. W. Patch, H. E. Royce, G. A. Sanborn, C. M. Saville, E. M. Shedd, C. W. Sherman, J. Waldo Smith, G. H. Snell, Henry Souther, G. A. Stacy, J. T. Stevens, L. A. Taylor, R. J. Thomas, H. L. Thomas, William H. Thomas, J. L. Tighe, D. N. Tower, W. H. Vaughn, C. K. Walker, R. S. Weston, J. C. Whitney, G. E. Wilde, F. I. Winslow, H. B. Wood. — 73.

HONORARY MEMBER.

F. W. Shepperd. — 1.

ASSOCIATES.

Builders Iron Foundry, by F. N. Connet; Coffin Valve Co., by H. L. Weston; Hersey Mfg. Co., by Albert S. Glover, J. A. Tilden and W. A. Hersey; Henry F. Jenks; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; H. Mueller Mfg. Co., by W. L. Dickel; National Meter Co., by C. H. Baldwin and J. G. Lufkin; Neptune Meter Co., by William H. Van Winkle; Norwood Engineering Co., by H. W. Hosford; Perrin, Seamans & Co., by James C. Campbell; Rensselaer Mfg. Co., by Fred

S. Bates; Sweet & Doyle, by H. L. DeWolfe; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by F. L. Northrop, F. E. Hall and L. P. Anderson. — 20.

GUESTS.

A. E. Pickup, Water Registrar, and Hugh McLean, Water Commissioner, of Holyoke, Mass.; W. H. Patterson, Superintendent Water Works, Providence, R. I.; Edwin P. Longley, Marlboro, Mass.; F. L. Weaver, Chairman Water Board, Lowell, Mass.; Hon. Cornelius F. Lynch, Lawrence, Mass.; R. A. Thayer, Woonsocket, R. I.; Horace Hart, Boston; and John W. Kernan, Wakefield, Mass. — 9.

(Names counted twice. — 4.)

The following were elected to membership:

Resident Members. — A. E. Pickup, Water Registrar, Holyoke Water Works; Hugh McLean, Secretary Water Commissioners, Holyoke, Mass.

Non-Resident Member. — Edward S. Cole, in charge of Water Waste Investigation of New York City.

Associates. — Fred A. Houdlette, Boston, manufacturer and dealer in water works and sewage steel and iron supplies; Hart Packing Co., Boston, manufacturers of steam and water packings.

The President appointed Messrs. J. L. Tighe, of Holyoke, and Harry L. Thomas, of Hingham, tellers to canvass the ballots for officers for the ensuing year.

Mayor Lynch of Lawrence was then introduced, and he spoke as follows:

Mr. President and Gentlemen of the Water Works Association, — I am rather surprised to be called on for any remarks. Being newly elected mayor, I am hardly familiar with the workings of any of the departments as yet, but it gives me great pleasure to meet a body of men organized for the purposes for which you are associated. I think it is a benefit to the municipalities, as well as to the superintendents and the water boards of the different cities and towns, that you should have such an organization and should hold these meetings where you can interchange ideas in the line of your work. I think it makes men broader, and the broader they are in their ideas, the better ideas they get through association with others, the better it is for the cities that they represent.

I came here as the guest of the superintendent of our water

works, and I am very glad I came. I want to say, without flattery, that we are favored in Lawrence by having as the superintendent of our water department a man in whom I believe all the citizens of Lawrence have perfect confidence, a man whose character for honesty and ability to perform the duties of the office is without question. [Applause.]

THE PRESIDENT'S ANNUAL ADDRESS.

President Walker addressed the Association as follows:

TO THE MEMBERS OF THE NEW ENGLAND WATER WORKS ASSOCIATION:

Gentlemen,—Another year has come and gone, and with it many pleasant days and remembrances that I have experienced with this organization.

Merrill, Kent, and Sherman told me at the time I was elected that they would assist and do whatever they could to make it easy for me in my present office. They have more than fulfilled their verbal contract, and I wish to thank these gentlemen to-day for their assistance and coöperation.

Of the twenty-one past presidents, eight have died, and the rest still belong to this Association. You will notice from the list that we have lost by death during the year three active members, namely, Joel Foster, of Montpelier, Vt.; Charles F. Parks, 14 Beacon Street, Boston; and George A. Ellis, of Springfield, Mass.; also two honorary members, namely, Alphonse Eteley, of New York City, and James M. Gale, of Glasgow, Scotland.

As you will learn from the Secretary's report, our total membership to-day is less by one than it was a year ago. We now have 586 members of all classes on our rolls.

When this Society was formed in April, 1882, it was for the purpose of meeting together to talk over the experiences which we had in our own cities and by getting the experiences of others, to make these meetings a mutual benefit to all of us in the Water Works Department. I shall never forget the first meeting that we had. The acquaintances that I made then have made my life happier, and what I have since learned has been a great benefit to me.

This year we have settled one question, — that the water furnished for fire sprinklers should be paid for; in what way has not been settled. We do not care how we get it, but we should be paid for the water furnished.

We have got the specifications for cast-iron pipe, and I, for one, will stick to them, for they suit me the best.

We have had interesting meetings and two excursions. The one in June was very pleasant and the sail up the Charles River, which has since been a noted place for canoeing, was a very pleasant trip for me. The watch factory was quite a curiosity, and I shall always feel indebted to my friend Winslow for having this trip made during my administration. The trip to Montreal was the best of the season, — and cost the most money, — but no one regrets it on that account. The whole thing was a success, the weather was perfect, and the ride through the mountains was immense. We must give Merrill and Holden credit for this excursion to a foreign land, which some of us never expected to see. Thanking you for the many favors received, I bespeak for my successor in the office of President, which I shall soon vacate, the same courtesy and kindness which you have all shown to me. [Applause.]

REPORT OF THE SECRETARY.

Secretary Kent submitted the following annual report, which, on motion of Mr. Cassell, was accepted and ordered to be placed on file:

Mr. President and Gentlemen of the New England Water Works Association, — I have the honor to submit the following report of membership, receipts, and disbursements of the New England Water Works Association for the year ending December 31, 1903.

MEMBERSHIP.

The total membership of the Association, January 1, 1903, was	587
The present membership (January 1, 1904) is	586

The membership is divided as follows:

MEMBERS.

Total active membership, January 1, 1903, was	522	
Withdrawals during past year:		
Resignations	22	
Dropped	26	
Died	3	51
	<hr/>	471
Initiations during past year:		
January	7	
February	5	
March	5	
June	7	
September	24	
November	3	
December	5	56
	<hr/>	
Reinstated	1	528
	<hr/>	

HONORARY MEMBERS.

Number of honorary members, January 1, 1903, was . . .	5	
Died during year	2	3
	<hr/>	

ASSOCIATES.

Total associate membership, January 1, 1903, was	60	
Withdrawals:		
Resignations	5	
Dropped	3	8
	<hr/>	52
Initiations during past year:		
September	3	3
	<hr/>	55
Total membership, January 1, 1904, is		586

SUMMARY OF RECEIPTS AND DISBURSEMENTS OF THE NEW ENGLAND WATER
WORKS ASSOCIATION FOR THE YEAR 1903.

RECEIPTS.

Dues	\$2 540.50
Advertisements	1 539.75
Initiations	340.00
JOURNALS sold	219.08
Subscriptions	157.25
Sales of Pipe Specifications	116.90
Sundries	29.42
	<hr/>
	\$4 942.90

DISBURSEMENTS.

JOURNAL (including membership list)	\$1 526.66
Stationery	425.61
Rent	400.00
Assistant Secretary	390.00
Editor	300.00
Advertising Agent	280.10
Incidental Expenses	240.38
Secretary	200.00
Reprints	167.75
Pipe Specifications	139.40
September Excursion	112.59
Stenographer	107.25
Badges	62.11
Stereopticon	58.00
Music	50.00
Exhibit	34.60
June Excursion	10.63
Total	<hr/> \$4 505.08
Amount of Receipts above Expenditures	\$437.82
At the present time there is due the Association:	
For dues	\$240.75
For advertisements	171.25
For sundries	4.80
Total	<hr/> \$416.80

The bill for the printing of the December issue of the JOURNAL is not yet received.

I know of no other outstanding bills against the Association.

Respectfully submitted,

WILLARD KENT, *Secretary*.

REPORT OF THE TREASURER.

The Treasurer, Lewis M. Bancroft, submitted the following report, which, on motion of Mr. Frank L. Fuller, was accepted and placed on file:

LEWIS M. BANCROFT,
In account with The New England

RECEIPTS.

1903.

January	9.	Balance on hand	\$2 541.73	
August	1.	Dividend, People's Savings Bank	53.80	
December	6.	Dividend, Mechanics Savings Bank	35.70	
March	4.	Received of Willard Kent, Sec'y . . .	\$1 817.23	
April	15.	" " " "	616.79	
June	18.	" " " "	624.48	
July	14.	" " " "	111.50	
September	28.	" " " "	376.90	
December	4.	" " " "	798.90	
1903.				
January	4.	" " " "	597.10	4 942.90
				<u>\$7 574.13</u>

Examined and found correct.

E. J. CHADBOURNE,
Finance Committee.

TREASURER,
Water Works Association.

EXPENDITURES.

Bills paid, as per itemized statement following \$4 505.08

BALANCE ON HAND.

Deposit People's Savings Bank,	
Worcester	\$1 398.98
Deposit Mechanics Savings Bank,	
Reading	1 047.12
Deposit First National Bank, Read-	
ing	622.95
Balance on hand	3 069.05
	<hr/>
	\$7 574.13
	<hr/>

LEWIS M. BANCROFT,
Treasurer.

DETAILED STATEMENT OF BILLS PAID.

1903.

February	2.	Hobbs & Warren Co., paper	\$2.49
		Hub Engraving Co., plates	6.72
		Thomas P. Taylor, stereopticon, January meeting	10.00
	5.	Samuel Usher, printing	49.50
		Hub Engraving Co., plates	29.81
March	11.	J. M. Ham, salary and expenses Assistant Secretary to February 1.	34.35
		Hooper, Lewis & Co., letter book and cards	5.50
	4.	D. Gillies' Sons, envelopes and letter paper	93.44
		W. N. Hughes, bills and envelopes	15.25
		Hub Engraving Co., plates	17.20
		Edgar D. Sewall, drawings	16.25
		Amarina & Peters, music, January and February meetings	20.00
		Thomas P. Taylor, stereopticon, February meeting	10.00
		Helen A. Thomas, four days' services	6.65
	5.	D. Gillies' Sons, printing	5.39
		J. M. Ham, salary and expenses to March 1	57.00
		W. N. Hughes, large envelopes	47.75
		Boston Society of Civil Engineers, rent to February 26	100.00
	16.	Hub Engraving Co., plates	13.65
		Samuel Usher, printing	197.50
April		Amarina & Peters, music, March meeting	10.00
	24.	W. N. Hughes, bills	2.80
		Charles W. Sherman, salary to April 1 and expenses	82.30
	30.	Bacon & Burpee, reporting January, February, and March meetings	30.00
	4.	Robert J. Thomas, advertising agent to April 1	80.55
		J. M. Ham, salary and expenses to April 1	33.96
	6.	D. Gillies' Sons, blank book	7.85
		Samuel Usher, March JOURNAL	310.95
		Hub Engraving Co., plates	16.19
	10.	Willard Kent, salary and expenses to March 31, Hooper, Lewis & Co., cards, etc.	90.70 1.50
	22.	Samuel Usher, reprints	25.75
Amount carried forward			\$1,431.00

		Amount brought forward	\$1 431.00
May	1.	William H. Lawrence, lantern slides	5.50
		American Society of Civil Engineers, binding transactions	6.40
	27.	J. M. Ham, salary to May 1	35.00
		Hub Engraving Co., plates	5.40
June	13.	Hub Engraving Co., plates	48.01
		J. M. Ham, salary for May	35.00
	19.	D. Gillies' Sons, printing circulars	4.85
		Library Bureau, pamphlet cases	10.88
	29.	Charles W. Sherman, salary and expenses to July 1	81.65
		George E. Winslow, tickets, etc., June outing	5.81
		Rand Avery Supply Co., tickets	1.50
		Frank E. Merrill, expense June outing	3.32
		Willard Kent, salary and expenses to July 1	61.00
July	6.	Samuel Usher, June JOURNAL	345.35
	9.	Samuel Usher, reprints	47.50
	15.	Robert J. Thomas, advertising agent to July 1, J. M. Ham, salary to July 1	72.05
		J. M. Ham, salary to July 1	35.00
	27.	Boston Society of Civil Engineers, rent to May 31	100.00
August	26.	Hub Engraving Co., plates	6.16
		Samuel Usher, printing	36.50
		Willard Kent, expenses of committee, September convention	75.00
		J. M. Ham, salary to August 1	35.00
September	5.	J. M. Ham, salary to September 1, express, postage, etc	60.42
	22.	Bishop Engraving & Printing Co., printing	14.25
		Hub Engraving Co., plates	21.18
		Library Bureau, cards and tray	3.41
		Whitehead & Hoag Co., badges	24.11
		W. F. Almy, badges	38.00
		W. N. Hughes, envelopes and printing	26.00
		Henry F. Jenks, expenses, committee on exhibits, Montreal convention	34.60
	29.	Thomas P. Taylor, stereopticon, Montreal convention	38.00
		Charles W. Sherman, salary, expenses, and postage to October 1	84.25
		Samuel Usher, reprints	34.00
		The Somerville Journal Co., printing	3.50
		Frank E. Merrill, telephone, telegraph, and express	5.59
		Amount carried forward	\$2 875.19

		Amount brought forward	\$2 875.19
September	29.	Car fare T. P. Taylor, Montreal and return . .	16.00
October	2.	D. Gillies' Sons, printing notices	72.00
		Willard Kent, salary to October 1 and ex- penses	73.00
	8.	J. M. Ham, salary to October 1	35.00
	13.	Robert J. Thomas, advertising agent, to Oc- tober 1	64.25
	21.	Hub Engraving Co., plates	33.51
		Boston Society of Civil Engineers, rent to August 31	100.00
	29.	Hub Engraving Co., plates	14.78
		George J. Sinnett, repairing furniture	2.50
		Buildings Cleaning & Renovating Co., cleaning	4.55
November	13.	J. M. Ham, salary to November 1	35.00
		D. Gillies' Sons, envelopes and printing . . .	35.20
	21.	J. Dennison, plates	43.33
		Charles W. Sherman, paid for drawings, duty on cuts, etc.	20.04
December	4.	Samuel Usher, September JOURNAL	360.24
		W. N. Hughes, binding books	5.00
	7.	Hub Engraving Co., plates	24.83
		Samuel Usher, reprints	29.75
		J. M. Ham, salary to December 1	35.00
		Bacon & Burpee, stenographers, September and November meetings	69.25
	14.	Hub Engraving Co., plates	4.24
		Library Bureau, card index of JOURNAL . . .	67.11
		Amarina & Peters, music, November and December meetings	20.00
	26.	Robert J. Thomas, advertising agent to Janu- ary 1, 1904	63.25
		Charles W. Sherman, salary and expenses to January 1, 1904	75.75
		J. M. Ham, salary to January 1, 1904	35.00
	29.	Bacon & Burpee, report of December meeting, Samuel Usher, printing	8.00
		Willard Kent, salary and expenses to Janu- ary 1, 1904	91.00
1904.			
January	2.	D. Gillies' Sons	40.70
	7.	Boston Society of Civil Engineers, rent to December 1, 1903	100.00
	12.	J. M. Ham, expenses to January 1, 1904 . . .	46.11
		• Total bills paid	\$4 505.08

REPORT OF THE EDITOR.

Mr. Charles W. Sherman, the editor, submitted the following report, which, on motion of Mr. Stacy, was accepted and placed on file:

BOSTON, January 13, 1904.

To the New England Water Works Association, — The following is my report as Editor of the JOURNAL for the year 1903:

The December issue of the JOURNAL, which has just appeared after many delays, contains twenty-five and one-quarter pages of paid advertisements, of an annual value of \$1 750. A year ago we had twenty-seven and one-third pages of paid advertisements of a value of \$1 929. This shows a loss of \$179 worth of advertisements during the year. Our advertising agent has been assiduous as ever in his attempts to secure and retain advertising, and the only conclusion to be drawn from the falling off of patronage is that the members do not pay sufficient attention to the advertising to make the advertising pages of sufficient value to those advertisers who have withdrawn.

As was the case a year ago, the December issue has been delayed to such a time that it has not been possible to send out bills for the advertising in that issue and get any returns from them. The receipts for 1904 will consequently show a considerable sum which properly belongs to the JOURNAL for 1903.

The accompanying tables show in detail the amount of material in the JOURNAL, the receipts and expenditures, and a comparison with the three preceding volumes.

TABLE No. 1.

STATEMENT OF MATERIAL IN VOLUME XVII, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1903.

Number.	DATE OF ISSUE.	NUMBER OF PAGES OF							
		Papers.	Proceedings.	Total Text.	Index, etc.	Advertisements.	Covers and Contents.	Inset Plates.	Total.
1	March	96	30	126	—	34	4	2	166
2	June	104	4	108	—	31	4	12	155
3	September	63	7	70	—	27	4	14	115
4	December	113	13	126	10	27	4	16	183
	Total	376	54	430	10	119	16	44	619

TABLE No. 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XVII, JOURNAL
OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1903.

RECEIPTS.		EXPENDITURES.	
From advertisements . . .	\$1 539.75	For printing JOURNAL . .	\$1 433.09*
From sale of JOURNALS . .	219.08	For preparing illustra-	
From sale of reprints . . .	19.35	tions	314.76
From subscriptions	157.25	For Editor's salary . . .	300.00
		For Editor's incidentals .	30.49
	\$1 935.43	For Advertising Agent's	
		commissions	280.10
		For reporting	107.25
		For reprints and advance	
		copies	167.75
		For statistics forms . . .	5.50
Net cost of JOURNAL . . .	770.62	For index to JOURNAL . .	67.11
	\$2 706.05	Gross cost of JOURNAL .	\$2 706.05*

* This includes bill for December JOURNAL, which has just been received but not paid, and consequently does not appear in the Secretary's and Treasurer's reports.

TABLE No. 3.

COMPARISON BETWEEN VOLUMES XIV, XV (4 NUMBERS), XVI, AND XVII,
JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

	<i>Vol. xiv.</i>	<i>4 numbers of Vol. xv.</i>	<i>Vol. xvi.</i>	<i>Vol. xvii.</i>
Edition (copies)	1 100	1 200	1 200	1 200
Average membership	583	586	571	587
Pages of text	345	363	403	430
Pages of text per 1 000 members	600	618	707	733
Total pages, all kinds	485	536	584	619
Total pages per 1 000 members	832	913	1 020	1 051
GROSS COST:				
Total	\$1 954.15	\$2 194.26	\$2 439.99	\$2 706.05
Per page	4.03	4.10	4.18	4.38
Per member	3.35	3.75	4.27	4.61
Per member per 1 000 pages .	6.91	6.99	7.32	7.46
Per member per 1 000 pp. text	9.71	10.31	10.60	10.72
NET COST:				
Total	\$347.55	\$332.90	\$622.89	\$770.62
Per page . . . . .	.72	.62	1.07	1.25
Per member . . . . .	.60	.57	1.09	1.31
Per member per 1 000 pages .	1.23	1.06	1.87	2.12
Per member per 1 000 pp. text	1.73	1.57	2.71	3.05

Without crediting the JOURNAL with any part of the dues paid by members, it will be observed that the expenses incurred on account of the JOURNAL amount to \$770.62 more than the receipts. This is a larger net cost than we have had for some years, if ever before. It is largely accounted for, however, by the extra work undertaken; first in preparing a complete card index to the JOURNAL from the beginning, which has now been completed and installed at headquarters, and, second, in working up tables and making cuts to accompany the "Standard Specifications for Cast Iron Pipes and Special Castings."

Three thousand copies of the Standard Specifications have been printed in a separate pamphlet, most of which have been sold. The cost of printing and sending out specifications has been \$139.40, and the receipts from sales \$116.90, leaving a net cost to the Association of \$22.50. This, however, does not include any of the expenses of preparing tables, illustrations, etc., all of which have been charged to the JOURNAL.

The usual fifty reprints of papers have been furnished to their authors without charge. The net cost to the Association of these reprints, including also advance copies of one or two papers, has been \$5.94 for each paper reprinted.

The total cost of illustrations for this volume, including payments for drafting, making cuts, and printing inset plates, has been \$508.01, or 18.75 per cent. of the gross cost of the JOURNAL.

The present circulation of the JOURNAL is:

Members (all grades)	586
Subscribers	52
Exchanges	18

The custom of sending out three hundred sample copies of each issue has been continued through the year.

The December issue having appeared so recently, the reprints from it have not yet been delivered and consequently the bill for these reprints has not been received. With this exception, I know of no outstanding bills against the Association on account of the JOURNAL.

Respectfully submitted,

CHARLES W. SHERMAN, *Editor*.

Mr. George A. Stacy read a paper by W. C. Hawley, General Superintendent Pennsylvania Water Co., Wilkinsburg, Pa., entitled, "Some Notes on Cost of Waterproofing Concrete Lining of Reservoirs." The subject was discussed by J. Waldo Smith, Frank L. Fuller, Edward S. Larned, and Robert J. Thomas.

ELECTION OF OFFICERS.

The tellers appointed to canvass ballots for officers for the ensuing year reported as follows:

Total number of ballots 219

For President.

EDWIN C. BROOKS, Cambridge, Mass. 208
C. K. WALKER 3

For Vice-Presidents.

V. C. HASTINGS, Concord, N. H. 207
GEORGE P. WESCOTT, Portland, Me. 207
JOSEPH E. BEALS, Middleboro, Mass. 208
E. W. KENT, Woonsocket, R. I. 208
GEORGE E. CROWELL, Brattleboro, Vt. 207
J. C. HAMMOND, Jr., Rockville, Conn. 208

For Secretary.

WILLARD KENT, Narragansett Pier, R. I. 211

For Treasurer.

LEWIS M. BANCROFT, Reading, Mass. 209

For Editor.

CHARLES W. SHERMAN, Boston, Mass. 208
ALLEN HAZEN 1

For Advertising Agent.

ROBERT J. THOMAS, Lowell, Mass. 209
FRED BATES * 1

For Additional Members of Executive Committee.

FRANK E. MERRILL, Somerville, Mass. 207
GEORGE A. STACY, Marlboro, Mass. 207
H. G. HOLDEN, Nashua, N. H. 207

For Finance Committee.

E. J. CHADBOURNE, Wakefield, Mass. 207
R. C. P. COGGESHALL, New Bedford, Mass. 210
W. W. ROBERTSON, Fall River, Mass. 207
D. W. FRENCH 1

* Ineligible.

President Walker in calling the newly elected President to the chair spoke as follows: I now present to you your new President, Mr. Brooks, of Cambridge. He holds the place once filled by Hiram Nevons, who was our fourth President, I think, and the Association then had two hundred and seventy-three members. We all used to like him very much, and I hope we will like his successor as well. Mr. Brooks is probably the best mechanical engineer who has ever been President of this Association. I hope he will have as nice a time being President as I have had, and I will now step down and out. [Applause.]

Mr. Brooks then took the chair and said: Gentlemen, I sincerely thank you for the honor you have conferred upon me, and hope that at the end of the year you will not have had cause to regret it.

William Lyman Underwood, Lecturer, Massachusetts Institute of Technology, Boston, then spoke on "Mosquitoes, with Suggestions for their Extermination." His remarks were illustrated by the stereopticon with photographs taken from life. Questions were asked and remarks made by Freeman C. Coffin, Frank L. Fuller, Robert J. Thomas, Harrison P. Eddy, S. A. Agnew, and F. W. Dean. On motion of Charles W. Sherman, a vote of thanks was tendered to Mr. Underwood for his very interesting address.

Freeman C. Coffin, Civil and Hydraulic Engineer, Boston, Mass., read a paper on "Meter Rates," and at its conclusion moved the adoption of the following vote:

That a committee of this Association be appointed to consider the question of meter rates for water service, collect and digest information, and submit to the Association a schedule or schedules designed to meet various conditions of a metered service, or a basis upon which such schedules can be arranged; that this committee consist of five members; that the committee be authorized to expend a sum not exceeding fifty dollars in printing, postage, and other necessary expenses involved in the collection of data.

Messrs. Frank L. Fuller, F. E. Merrill, and Charles W. Sherman spoke in favor of the motion, and it was adopted. The Chair announced that he would appoint the committee later. Subse-

quently Messrs. Freeman C. Coffin, C. M. Saville, G. P. Wescott, H. V. Macksey, and F. E. Merrill were appointed members of the committee.

PRESIDENT BROOKS. I want to say a word in regard to the coming year. I wish we might have more little practical points in water-works management brought up and discussed at the meetings. It seems to me that I hardly ever meet a superintendent and talk with him but what I find he has some little kink that is of use. Perhaps he does not think it of importance enough to communicate to others, but really it amounts to quite a little oftentimes; and I think we all might gain something from a freer interchange of ideas here.

MR. F. W. DEAN. I should like to ask how the subjects for the papers are determined in this Association, — whether they are originated by the Secretary, or whether he gets suggestions from other people to any great extent.

THE PRESIDENT. Mr. Secretary, you will please answer.

SECRETARY KENT. The Secretary is always very glad to get suggestions from other people, but as matter of fact it is usually a case of hustle with him.

MR. DEAN. When the President spoke of the matter of relating experiences it occurred to me that perhaps it might be interesting to state how the New England Railroad Club proceeds to have papers brought forward for discussion. I am a member of that club and have been a member of the committee of which I shall speak. The club has monthly meetings for eight months in the year, the second Tuesday of each month, and there is a sub-committee of eight or ten members, which committee gets together as many times as may be necessary during the summer and selects a list of subjects for the following year. After that is once done the series of meetings goes along very easily. Of course there is considerable correspondence in regard to it, and the committee often gets people from out of town, as well as members of the club, to present papers on various subjects. Then theoretically we have a list of subjects for discussion aside from the papers, the idea being to have subjects for short discussions, so as to fill in any gaps if the regular papers are not long enough to take up the usual time of the meeting. Almost always, how-

ever, the papers are long enough, and so these short discussions seldom take place. It occurred to me if the Secretary is at all embarrassed in getting papers, it might be well for the Association to have a sub-committee for that purpose.

THE SECRETARY. I think that is a very good suggestion, Mr. President.

MR. CHARLES W. SHERMAN. I move that the President be authorized to appoint such a committee at his discretion. Adopted.

Adjourned.

FEBRUARY MEETING.

HOTEL BRUNSWICK,

BOSTON, MASS., February 10, 1904.

President Edwin C. Brooks in the chair.

The following members and guests were present:

MEMBERS.

S. A. Agnew, C. H. Baldwin, L. M. Baneroft, William T. Barnes, J. E. Beals, George Bowers, E. C. Brooks, Fred. Brooks, George Cassell, G. F. Chace, J. C. Chase, F. C. Coffin, R. C. P. Coggeshall, M. F. Collins, F. H. Crandall, Gorham Dana, C. H. Eglee, F. F. Forbes, A. D. Fuller, F. L. Fuller, A. S. Glover, J. W. Goodell, X. H. Goodnough, F. W. Gow, R. A. Hale, J. O. Hall, V. C. Hastings, H. G. Holden, H. R. Johnson, E. W. Kent, Willard Kent, G. A. King, E. S. Larned, J. W. Locke, T. H. McKenzie, S. H. McKenzie, H. V. Macksey, W. E. Maybury, F. E. Merrill, T. L. Northrop, J. H. Perkins, W. W. Robertson, C. W. Sherman, G. H. Snell, G. A. Stacy, J. T. Stevens, R. J. Thomas, J. L. Tighe, W. H. Vaughn, C. K. Walker, F. I. Winslow, G. E. Winslow. — 52.

ASSOCIATES.

Ashton Valve Co., by C. W. Houghton; Harold L. Bond & Co., by Harold L. Bond; Builders Iron Foundry, by F. N. Connet; Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; Garlock Packing Co., by Edward N. Corning; Hersey Mfg. Co., by Albert S. Glover, J. A. Tilden, and Walter A. Hersey; Fred A. Houdlette & Son, by Fred A. Houdlette; Lead Lined Iron Pipe Co., by T. E. Dwyer; H. Mueller Mfg. Co., by W. L. Dickel; National Lead Co., by G. L. Whittemore; National Meter Co., by C. H. Baldwin and J. G. Lufkin; Neptune Meter Co., by W. H. Van Winkle and H. H. Kinsey; Rensselaer Mfg. Co., by Fred S. Bates; A. W. Chesterton & Co., by William M. Rea; Central Foundry Co., by Mark Dean; Sumner & Goodwin Co., by H. A. Gorham; Sweet & Doyle, by H. L. DeWolfe; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by F. L. Northrop. — 24.

GUESTS.

John Mayo, Superintendent Water Works, Bridgewater, Mass.; Frank L. Weaver, A. J. Dowd, Water Commissioners, Lowell, Mass.; T. V. Sullivan, Water Department, Boston; J. H. Caldwell, Deputy Water Commissioner, Boston; and H. J. Jernegan, General Freight Agent, B. & P. S. S. Co. — 6.

Names counted twice. — 3.

The Secretary presented the names of the following applicants for membership, all of whom were properly endorsed and approved by the Executive Committee:

For Resident Member. — Virgil R. Connor, Fairfield, Me., Trustee Kennebec Water District; S. A. Nye, Fairfield, Me., Trustee Kennebec Water District; Ira E. Getchell, Waterville, Me., Trustee Kennebec Water District; Dr. F. C. Thayer, Waterville, Me., Trustee Kennebec Water District; John Mayo, Superintendent Bridgewater Water Co., Bridgewater, Mass.; Frank H. Carter, Cliftondale, Mass., Civil Engineer, Assistant Engineer with Leonard Metcalf, of Boston; Louis D. Thorpe, West Medford, Mass., Civil Engineer, Principal Assistant to Freeman C. Coffin.

For Non-Resident Member. — Wm. M. Marple, Scranton, Pa., Chief Engineer of the Scranton Gas and Water Co., and other companies.

For Associate. — The Wm. Tod Co., Youngstown, Ohio, builders of high duty pumping engines.

On motion of Mr. Fuller the Secretary was empowered to cast one vote for the applicants whose names had been read, and he having done so they were declared elected.

PLACE OF ANNUAL CONVENTION.

THE PRESIDENT. I wish to announce that the invitation from Holyoke has been accepted, and the fall convention will be held there some time in September.

PROPOSED LEGISLATION AFFECTING PURITY OF WATER SUPPLIES.

I should like to say to the members from Massachusetts that there is a bill before the Legislature, Senate No. 87, that very seriously modifies and affects the rights of water-takers in the great ponds and streams of the state. In order that you may know more fully what some of the features of this bill are, I will ask Mr. Goodnough to speak to you.

MR. X. H. GOODNOUGH. *Mr. President and Gentlemen,* — This is Senate Bill No. 87 accompanying a petition for an amendment to the law relative to the pollution of water supplies of cities and towns, and it is now before the Public Health and Water Supply committees jointly. I will not read it all, but it is a modification of the present legislation authorizing the State Board of Health to make rules and regulations for the protection of water supplies. The bill is the most pernicious piece of proposed legislation affect-

ing the purity of water supplies that has appeared for some time. Its chief objectionable features are, first, that it provides that any one aggrieved by the enforcement of the rules and regulations of the Board of Health may recover damages; in other words, it authorizes people living about great ponds to recover damages for the exercise of police power — a new thing in law, I believe. The other chief objectionable feature is found in Section 2: "The State Board of Health shall not make rules or regulations or orders prohibiting or restricting boating, fishing, or ice cutting on any great pond." The effect of that, of course, would be that the surfaces of great ponds may be used as pleasure resorts without any restriction whatever. People might launch boats, and as has happened in one case, might launch house boats on a pond and anchor them over an intake, if they saw fit, and no authority could remove them. The water supplies of this state are used by something like 92 per cent. of the population, five sixths of whom are dependent upon supplies taken from surface sources, very largely from great ponds, and it is essential that the purity of those waters should be protected.

In recent years there has been a very rapid growth in the use of ponds and reservoirs, especially great ponds, as summer resorts, and there has been a very rapid growth in the number of cottages about those ponds and in picnic and other pleasure resorts on their shores, which the rules of the Board of Health have been invoked to prevent. This proposed legislation is really for the benefit of the very few to the injury of the very great majority. The legislation to protect our water supplies has grown up, I may say, since 1878, when the first act was passed to prohibit their pollution. That is the act which is sometimes known as the twenty-mile law, and it provided that no sewage should be discharged into a stream or pond within twenty miles of the point from which water is taken for a public supply. In 1890 the first act giving the State Board of Health authority to make rules and regulations was passed. That was revised and the powers of the Board greatly enlarged by the act of 1897, which was changed somewhat when the Revised Laws were established in 1902.

One object of this proposed law is to provide, or is said to be to provide, for an appeal to a jury for the revision of the rules of the Board. Of course we all know the danger of submitting

such matters to a jury, especially the protection of public water supplies. It is argued that in some cases the waters could be protected by filtration. That is a very good method of protecting a public water supply, but it is needless to say that filtration is not the only protection, and no one wants to drink water that has been polluted by sewage, even if it has subsequently been purified by filtration. It is essential to keep the sources pure in the beginning. It is hoped that those who are interested in this legislation, and nearly all the water-works men in the state should be, will take an active interest at least so far as to appear at the hearing when the matter comes up. The date of the hearing has not yet been assigned.

THE PRESIDENT. I will ask Mr. King, of Taunton, to favor us with a few remarks.

MR. GEORGE A. KING. *Mr. President and Gentlemen*, — I suppose this bill was aimed directly at Taunton, but it will affect every city or town which has had rules made for it by the State Board of Health, or any which may have them made in the future. It opens a great source of damage cases, and any party who lives on the watershed of a water supply will have an opportunity to bring a suit for damages, and the same body which has the power to amend or annul the rules, that is, the jury, will have the power to assess the damages; and as these damages will be assessed in the county where the land lies it will probably be hard to get a fair jury as between the individual and the municipality or the owner of the water supply. I think, as Mr. Goodnough has said, that this would be a most pernicious piece of legislation, and I would like to have the assistance of all the water-works people in the attempt to defeat the bill. If you will see the members of the House and Senate from your various sections, I think we can easily defeat it. Of course the cottagers have considerable money to spend on this matter and the cities and towns haven't much, so we must depend on our individual efforts.

THE PRESIDENT. Mr. Chace, will you say something?

MR. GEORGE F. CHACE. Mr. President, I think this is a very important matter. It seems to me it would be a good thing if there were some organized action on the part of this Association by the appointment of a committee to make an active opposition to the bill, and I would move that a committee be appointed by the Chair to attend the hearing.

THE PRESIDENT. I must say that I have had some doubts as to whether it was best for the Association to take action in this matter as an Association, and my idea in bringing up this discussion was that the Massachusetts superintendents might be informed as to what was pending, so that they could use their individual efforts with the members of the Legislature from their respective districts to defeat the proposed bill. Of course this is a New England organization and not merely a Massachusetts organization, and it is a question in my mind whether it would be policy for us to take action as an association in regard to this matter. I shall be happy to hear from any of the members on the subject, for I think it is one which is worthy of discussion.

MR. R. C. P. COGGESHALL. Perhaps some such action as advising the Massachusetts members when the hearing on this bill is to be held, might help to defeat the measure.

THE PRESIDENT. Can we hear from Ex-Mayor Hall on this matter?

MR. JOHN O. HALL. I do not know as I can add anything to what has been said, Mr. President, but I think it certainly is the duty of the Massachusetts members of the New England Water Works Association to interest themselves and be active in their opposition to this measure. It certainly is of vital importance that it should be defeated, and we should all use our best efforts to sustain the State Board of Health in their very successful measures to ensure the purity of the water supplied to our people. And while it seems to me no action could properly be taken before the Legislature by us as an organization, I trust that every individual member of the Association who lives in Massachusetts will give it his personal attention.

MR. M. F. COLLINS. It strikes me, Mr. President, that one of the duties of this organization, when a question of this kind comes up, is to act upon it as a body. If this proposed legislation is against the best interests of the water-takers of New England, then I think this Association ought to be used for the purpose of defeating it. I think it comes with good grace for this Association to take action as a body on such a question as this. It stands well in Massachusetts, and its opinion will have some weight. Then, after we have acted here, let every member of the Association work on the Representatives from his district

individually, backed up by the voice of this Association, which is organized for the very purpose of looking after the interests of the water-takers of New England. In order to bring the matter properly before the Association, I move that a committee be appointed to appear before the Legislative Committee and represent the New England Water Works Association.

MR. CHARLES K. WALKER. Before the motion is seconded I have a little to say. I think Mr. Coggeshall has the right of it. We in New Hampshire are not interested in the Massachusetts Legislature, and in what they do or in what they do not do. Now if you take a vote here of the Association you bring in representatives from every state in New England, and is that right? If you have some trouble here in your Massachusetts Legislature, why shouldn't the representatives of Massachusetts attend to it, and why isn't the best way to do as was done before — merely notify the Massachusetts members of the Association in regard to the matter? If we vote as an Association, I have got to vote, and I live in New Hampshire, and New Hampshire hasn't anything to do with Massachusetts water.

MR. J. O. HALL. It seems to me it will be very much better for the Association to act through the individual members rather than to take any special action as a body. I would like to say that I am president of the Massachusetts Auditors Association, and we have under consideration the question of what is called uniform accounting. A motion was made in that association that we send a committee to the Legislature this winter to represent us in the interest of a certain bill. Objection was made by some of the best auditors in the state, the most level-headed and thoughtful of the members, that there would attach to such action a certain political element which would be objectionable and would be of disadvantage to the association. And it seems to me that the same argument holds good in the consideration of the question now before us. This is an organization intended for the advancement of the scientific and mechanical and financial elements in water-works problems, and there is a certain element of a political nature which enters into this bill, and if we were to send a committee to the Legislature, with the authority of the Association back of it, it seems to me that it might be an element of weakness in the presentation of the case. I think that this

thing can be reached and fully presented and earnestly and effectively argued against if each member of the Association acts individually and to a certain extent independently. In that way any question of political action would be avoided and the same result would be accomplished.

MR. CHARLES W. SHERMAN. I am inclined to agree with Mr. Hall's views. I think, however, as Mr. Collins does, that the Association should concern itself with such a matter as this, certainly to the extent of discussing the matter as we have to-day, and that it would also be entirely in order for the Association to go a little further and authorize the expenditure of a small sum of money in printing a notice that this bill is coming up, and that the matter has been talked over at the meeting to-day, giving a brief statement of what the effect of the passage of the bill would be, and mailing the notices to each Massachusetts member of the Association, and also to every water-works superintendent in Massachusetts who is not a member of the Association, with the suggestion that if members agree with the opinions expressed here to-day they use their best endeavors with their Senators and Representatives to defeat the bill; and also if convenient that they attend the hearings. And as the other motion has not been seconded, if it is in order, I will make a motion that the Secretary be authorized to issue a brief circular describing this bill and suggesting that members interest themselves in it, and call the attention of their Representatives in the Legislature to the effect that the passage of the bill would have.

MR. J. C. CHASE. I would like to present one point of view very briefly in this connection, and that is, Would the Association consider itself called upon to interfere in case such legislation as this was attempted in any other New England state except Massachusetts?

THE PRESIDENT. Is Mr. Collins' motion seconded? If not, is Mr. Sherman's motion seconded?

MR. L. M. BANCROFT. I second Mr. Sherman's motion.

MR. SHERMAN. Before the motion is put I would like to say, in answer to Mr. Chase's question as to whether similar action would be taken if such legislation were proposed in any other state than Massachusetts, that I think it would be entirely proper for the Association to interest itself to the same extent in regard

to legislation in any of the New England states. But I think it is especially proper in this case, inasmuch as the sanitary legislation for the protection of water supplies in Massachusetts is looked upon throughout the country, and almost throughout the world, as a model to be followed.

MR. GOODNOUGH. I should like to suggest as an amendment to Mr. Sherman's motion that notice be sent out by the Secretary giving the time assigned for the hearing.

MR. SHERMAN. I accept that amendment.

MR. COLLINS. And I would like to have Mr. Sherman added to the committee to act with the Secretary.

MR. J. E. BEALS. I would like to suggest also that a copy of the bill that is to be presented be sent out with the notices.

(Mr. Sherman's motion as amended was adopted.)

THE PRESIDENT. Now in regard to the composition of this committee, perhaps it might be well to have more than the Secretary and Editor on the committee; what is your pleasure in regard to that?

MR. WILLARD KENT. I move that Mr. Goodnough and Mr. King be added to the committee.

Adopted.

Mr. Goodnough asked to be excused from serving on the committee, on the ground that the matter was coming before the Board of Health in rather an official way. Mr. G. A. Stacy was suggested, and he was added to the committee.

The first paper of the afternoon consisted of extracts from "Report Relative to supplying the City of New York with Pure and Wholesome Water, November, 1833," compiled by James M. Betton, of New York City, and read by Charles W. Sherman.

The next paper was by J. H. Purdy, of Pittsburgh, Pa., entitled, "Fire Protection for Factories: How its Value shall be Determined and Who shall Pay for It." In the absence of Mr. Purdy, Mr. F. H. Crandall read the paper, and he also read a report of progress by the Committee on Private Fire Services. The reading of the paper and of the report was followed by an exhibition by Mr. Crandall of stereopticon views of the apparatus used in the experiments at Knoxville and Burlington. The discussion was participated in by Messrs. T. H. McKenzie, Gorham Dana, Robert J. Thomas, John C. Chase, E. W. Kent, Frederick N. Connet, and Leonard Metcalf.

The President then brought up the subject of the freezing of meters during the past winter, and experiences were related by Messrs. E. W. Kent, Horace G. Holden, Robert J. Thomas, George A. King, George F. Chace, W. W. Robertson, A. E. Martin, Frank L. Fuller, Lewis M. Bancroft, and M. F. Collins.

On motion of Mr. Holden, adjourned.

EXECUTIVE COMMITTEE.

The Executive Committee met at headquarters, Tremont Temple, at 12 m., Wednesday, December 9, 1903. Present: President Charles K. Walker and Messrs. V. C. Hastings, E. C. Brooks, H. G. Holden, L. M. Bancroft, Willard Kent, R. J. Thomas, and C. W. Sherman.

Five applications for membership were received, and it was voted to recommend the applicants to the Association for election.

An invitation to hold the next annual convention in Holyoke was received. It was voted that the President appoint a committee of three to consider and report upon the places for holding the next annual convention, and also the June meeting.

Voted, that the Editor be authorized to make arrangements for discontinuing the sending out of three hundred sample copies of each issue of the JOURNAL, at his discretion.

Adjourned.

WILLARD KENT, *Secretary*.

JANUARY 13, 1904.

The Executive Committee met at headquarters, at 11.30 a.m. Present: President Charles K. Walker and Messrs. H. G. Holden, J. C. Hammond, Jr., R. J. Thomas, L. M. Bancroft, C. W. Sherman, and Willard Kent. Five applications for admission to the Association (three as member and two as associate) were received, and it was voted to recommend the applicants for ballot.

Adjourned.

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WILLARD KENT, *Secretary*.

FEBRUARY 10, 1904.

Present: President Brooks and Messrs. E. W. Kent, Willard Kent, H. G. Holden, V. C. Hastings, L. M. Bancroft, G. A. Stacy, C. W. Sherman, F. E. Merrill, J. E. Beals, and R. J. Thomas.

Eight applications for member and one for associate were considered, and it was voted to recommend the applicants to the Association for ballot.

The question of the necessity for additional room at headquarters was discussed.

The committee previously appointed to consider the place for the annual convention of 1904 reported in favor of Holyoke, Mass., and the Executive Committee voted that the convention be at Holyoke.

Treasurer Bancroft suggested that the Treasurer of the Association ought to give a bond. After discussion, it was voted that the President, Secretary, and Editor be a committee to purchase a suitable surety-company bond for the Treasurer, at the expense of the Association.

The question of election of honorary members was discussed, and it was voted that the President appoint a committee of three to consider the question and to report names for election to honorary membership if in their judgment it is desirable. The President appointed Messrs. Sherman, Willard Kent, and Holden on that committee.

Attention was called to Senate Bill No. 87, now before the Massachusetts Legislature, which would result in removing most if not all sanitary protection of water supplies. It was decided that the Association ought not to appear by a committee before the committees of the Legislature, but that attention of members should be called to the bill and such proper action taken as the meeting might decide.

Adjourned.

WILLARD KENT, *Secretary*.

OBITUARY.

ALPHONSE FTELEY, Civil Engineer, an honorary member of the New England Water Works Association, died June 11, 1903.

Mr. Fteley was born in Paris, France, April 10, 1837. He received his professional education at the Ecole Polytechnique in Paris, from which he was graduated in 1859. After six years of varied engineering work in France, he came to the United States in 1865. From 1866 to 1870 he was general assistant to William E. Worthen, on miscellaneous civil, hydraulic, and mechanical engineering work. In 1870 he opened an office in New York City for general engineering practice.

In May, 1873, Mr. Fteley was called to Boston to take charge, under Joseph P. Davis, City Engineer, of the construction of the Sudbury River Water Works. This work, with many additional investigations connected therewith, continued until 1880. During his connection with this work, the accurate gagings of the flow of the Sudbury River were begun, and at this time he also carried out, in connection with his assistant, Mr. Frederic P. Stearns, important experiments on the flow of water over weirs and through aqueducts and upon the accuracy of current meters.

From 1880 to 1884 Mr. Fteley was Chief Assistant City Engineer of Boston. In January, 1884, he accepted the position of Principal Assistant and Executive Engineer on the Croton Aqueduct, New York, under Mr. Benjamin S. Church, Chief Engineer. In 1886 Mr. Fteley became Consulting Engineer of this work. In 1888 he was appointed Chief Engineer of the Aqueduct Commission, and continued in this position until failing health made it necessary for him to resign at the end of 1899. While occupying this position, Mr. Fteley had charge of the design and construction of very important works, including the Jerome Park Reservoir and the New Croton Dam and other dams upon the Croton River and its branches.

After retiring from active practice, Mr. Fteley's failing health required him to avoid all physical exertion, but his mental powers remained undiminished and he attended to a limited amount of consulting work.

Mr. Fteley was a member of the Boston Society of Civil Engineers, and also the American Society of Civil Engineers, of which he was president in 1898. He was elected a member of the New England Water Works Association June 18, 1885, and an honorary member September 10, 1902.

MR. GEORGE A. ELLIS, Civil Engineer, who for nearly fourteen years was City Engineer of Springfield, Mass., died at his home in that city on December 27, after suffering for a period of eighteen months from valvular disease of the heart.

Mr. Ellis had of late years been acting as a consulting engineer, and had been engaged on many important works throughout the country. He was born in Ashland in 1843; was City Engineer of Springfield from 1874 to 1886; was appointed Chief Engineer of the Springfield, Athol & Northeastern R. R. in 1873, which position he held for a short time, as he did also that of Superintendent; acted as Chief Engineer in the construction of part of the Longmeadow & Springfield R. R.; has had charge of the installation of water systems at Racine, Wis.; Montgomery, Ala.; Sharon, Mass.; Marion, Ohio; and in other towns, and in recent years has been connected with the construction of electric railways.

Mr. Ellis was elected a member of the England Water Works Association on June 21, 1883, and was its third president, serving for the year 1884-85. His portrait was printed in the JOURNAL of December, 1902 (Vol. 16, No. 4), where it faces page 280.

NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XVIII.

June, 1904.

No. 2.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

REPORT ON THE MEASUREMENT, CONSUMPTION AND WASTE OF WATER SUPPLIED TO THE METROPOLITAN WATER DISTRICT.

BY DEXTER BRACKETT, ENGINEER OF THE DISTRIBUTION DEPARTMENT, METROPOLITAN WATER WORKS.

To the Metropolitan Water and Sewerage Board.

GENTLEMEN : — The following report contains the results of work done and investigations made under authority of chapter 391 of the Acts of the General Court for the year 1902, which authorized the construction of works for measuring the water used in each of the cities and towns in the Metropolitan Water District, and directed the Board to report the quantity supplied to each of the cities and towns, and also whether water is being unnecessarily or improperly used, and to make recommendations regarding the prevention of waste, and the manner of apportioning the annual assessment among the cities and towns.

The Metropolitan Water Works supply water to 18 cities and towns, having, on May 1, 1903, an estimated aggregate population of 897,600, and comprising a territory of 142.7 square miles in area, the greater portion of which lies within a radius of 10 miles

ERRATUM.

In JOURNAL of December, 1903, page 311, line 14, for 2.0452
read 2.0425.

The area, population, number of service pipes, meters and mileage of pipe in use in the several cities and towns are shown by Table No. 1.

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The Metropolitan Water Works supply water to 18 cities and towns, having, on May 1, 1903, an estimated aggregate population of 897,600, and comprising a territory of 142.7 square miles in area, the greater portion of which lies within a radius of 10 miles from the State House. Topographically, the part of this territory where the greater portion of the water is used is less than 50 feet above sea level. The greater part of the area included in the several municipalities is, however, at a higher elevation, and at one point in the town of Milton it rises to elevation 640 above Boston city base. Other summits in the District are: Arlington Heights, elevation 377; Bellevue Hill, in West Roxbury, elevation 340; and Bear Hill, in Stoneham, elevation 315.

The area, population, number of service pipes, meters and mileage of pipe in use in the several cities and towns are shown by Table No. 1.

TABLE NO. 1.

CITY OR TOWN.	Area (Square Miles).	Estimated Population, May 1, 1903.	Number of Services, January, 1903.	Number of Meters, January, 1903.	Per Cent. of Services metered.	Miles of Pipe.
Boston,	38.2	597,900	89,384	4,617	5.2	723.0
Somerville,	4.2	67,600	10,710	271	2.5	82.5
Malden,	4.9	36,900	6,700	4,245	63.4	82.0
Chelsea,	2.3	35,900	6,257	113	.2	38.7
Everett,	3.4	28,000	4,670	49	1.0	42.0
Quincy,	16.5	26,800	4,850	152	3.1	83.7
Medford,	7.1	21,000	4,039	124	3.1	50.4
Melrose,	5.1	13,900	3,221	95	3.0	44.5
Revere,	5.9	12,700	2,261	28	1.2	34.5
Watertown,	4.1	10,800	1,692	1,515	89.5	30.1
Arlington,	5.2	9,700	1,700	94	5.5	34.3
Milton,	12.9	7,400	1,078	1,078	100.0	35.0
Winthrop,	1.6	7,300	1,747	9	.5	22.7
Stoneham,	6.6	6,400	1,157	19	1.7	19.9
Belmont,	4.6	4,800	621	621	100.0	17.9
Lexington,	16.0	4,100	620	4	.6	11.7
Nahant,	1.0	1,300	462	43	9.3	15.9
Swampscott,	3.1	5,100	1,055	-	-	17.2
	142.7	897,600	142,224	13,077	9.2	1,386.0

Previous to the formation of the Metropolitan Water District nearly all of these cities and towns drew their supplies from different sources, and maintained separate reservoirs and pumping stations. Since the construction of the Metropolitan Works eleven sources of supply have been abandoned, and the pumping, which was formerly done at twenty stations, is now done at five stations. All water delivered by the Sudbury and Cochituate aqueducts is delivered by gravity into Chestnut Hill Reservoir, whence it is raised by pumping machinery to different elevations supplying separate districts. The water delivered by the Weston Aqueduct, which was completed and placed in service on December 29, 1903, is discharged directly into the low-service mains without any pumping.

For the southern low-service district, comprising the lower portion of the city of Boston, excepting in Charlestown and East Boston, the pressure at the pumping station at Chestnut Hill is

maintained so as to deliver water in the city at an elevation of about 130 feet above Boston city base at all times during day and night.

For the northern low-service district, including the lower portion of the cities of Somerville, Medford, Malden, Everett, Chelsea, and for Charlestown and East Boston, water is pumped into Spot Pond at elevation 163 above Boston city base.

For the southern high-service district, comprising Quincy, Watertown and Belmont, and the higher portion of the city of Boston, water is pumped from Chestnut Hill to the Fisher Hill and Waban Hill reservoirs. High-water mark in the Fisher Hill Reservoir is at elevation 251, and in Waban Hill Reservoir 264.5 feet above Boston city base.

For the northern high-service district, comprising the city of Melrose, the towns of Revere, Winthrop, Nahant, Swampscott and Stoneham and the higher portions of the cities of Somerville, Medford, Malden, Everett and Chelsea, water is pumped from Spot Pond to the Fells Reservoir at elevation 271, and to Bear Hill Reservoir at elevation 300. The town of Stoneham alone is supplied from the Bear Hill Reservoir.

For the town of Lexington and the higher portion of the town of Arlington, water is pumped from the low-service mains in Arlington to a standpipe on Arlington Heights at elevation 443. For the higher portion of the town of Milton and of the West Roxbury district of Boston, water is pumped to a standpipe on Mt. Bellevue, in West Roxbury, at elevation 376.

For the year 1902 the percentage of the total consumption used in the several districts was as follows:—

Southern low-service district,	40.0
Northern low-service district,	25.0
Southern high-service district,	27.0
Northern high-service district,	7.4
Northern extra high-service district, . . . . .	.3
Southern extra high-service district, . . . . .	.3

Table No. 2 shows the revenue received from water rates for the year 1902 in the several cities and towns supplied by the Metropolitan Works.

TABLE NO. 2.

CITY OR TOWN.	REVENUE FROM WATER RATES.			Revenue from Metered Water.	Per Cent. of Revenue from Metered Water.
	Received from Private Consumers.	Received from Municipalities.	Total.		
Boston,	\$2,306,191 98	*-	\$2,306,191 98	\$1,005,312 26	43.6
Somerville,	213,965 51	*-	213,965 51	50,733 53	23.7
Chelsea,	100,468 03	\$6,821 00	107,289 03	23,629 86	22.0
Malden,	95,968 95	1,143 29	97,112 24	68,403 08	70.5
Everett,	80,827 74	674 40	81,502 14	23,284 50	28.6
Quincy,	78,093 48	*-	78,093 48	14,452 65	18.5
Medford,	53,549 53	6,148 72	59,698 25	6,667 48	11.2
Melrose,	49,990 22	*-	49,990 22	3,041 54	6.1
Revere,	† 32,382 93	5,117 07	† 37,500 00	1,511 95	4.0
Watertown,	31,196 88	*-	31,196 88	30,034 88	96.3
Arlington,	35,721 89	*-	35,721 89	4,065 98	11.4
Milton,	27,694 68	11,155 70	38,850 38	38,850 38	100.0
Winthrop,	† 27,818 08	4,681 92	† 32,500 00	293 71	.9
Stoneham,	19,246 35	2,400 00	21,646 35	2,123 95	9.8
Belmont,	11,840 51	452 51	12,293 02	12,293 02	100.0
Lexington,	9,729 87	4,630 99	14,360 86	736 42	5.1
Nahant,	6,382 47	800 00	7,182 47	791 96	11.0
Swampscott,	17,104 33	1,435 50	18,539 83	-	-
	\$3,198,173 43	\$45,461 10	\$3,243,634 53	\$1,286,227 15	39.7

* No revenue received for water used for municipal purposes.

† Estimated.

MEASUREMENT OF WATER CONSUMED.

Before measurements and investigations could be made to determine the quantity of water used and wasted, it was necessary to provide means for measuring the water supplied to the several cities and towns. Previous to May 13, 1902, when the Act authorizing such measurement was approved, studies had been made to determine the best method of measuring the water used, and on June 20, 1902, a contract was made with the Builders Iron Foundry of Providence, R. I., for furnishing 42 Venturi meters, in sizes from 8 inches to 48 inches. These, with 3 meters previously purchased and set, and 4 meters which were subsequently ordered, make 49 meters which have been placed at the following points on the pipes supplying the several cities and towns: —

DISTRICT SUPPLIED BY METER.	Location of Meter.	Size of Meter (Inches).
Arlington, . . .	Medford Street, at Parallel Street,	20
Belmont, . . .	Common Street, at Belmont Street,	12
Boston (2 meters),	Low-service pumping station, Chestnut Hill Reservoir,	48
Boston,	Boylston Street, Brookline,	48
Boston,	Brookline Reservoir grounds, Brookline,	30
Boston,	Chestnut Hill Reservoir, near effluent gate chamber,	48
East Boston, . .	Condor Street, at Brooks Street,	24
Brighton, . . .	Chestnut Hill Avenue, at Beacon Street,	16
Charlestown, . .	Broadway, at Walnut Street, Somerville,	24
Charlestown, . .	Pearl Street, at Walnut Street, Somerville,	30
Charlestown, . .	Broadway, Chelsea, near North Bridge,	10
Dorchester, . . .	Morton Street, at Blue Hill Avenue,	16
Dorchester, . . .	River Street, at Morton Street,	12
West Roxbury, . .	Arborway, at South Street,	20
Chelsea,	Powder Horn Hill, at Chelsea Reservoir,	16
Chelsea,	Second Street, at Broadway,	24
Chelsea,	Second Street, Everett, at Locust Street,	12
Everett,	Broadway, at Hancock Street,	16
Everett,	Main Street, at Wyllis Avenue,	12
Everett,	Broadway, at Corey Street,	20
Lexington, . . .	Massachusetts Avenue, at Arlington-Lexington line,	12
Malden,	Highland Avenue, at Clifton Street,	16
Malden,	Hancock Street, at Cross Street,	12
Malden,	Washington Street, at Winter Street,	16
Malden,	Clifton Street, at Washington Street,	16
Malden,	Medford Street, at Pearl Street,	12
Malden,	Medford Street, at Green Street,	16
Medford,	Governors Avenue, at High Street,	10
Medford,	Boston Avenue, at College Avenue,	8
Medford,	Governors Avenue, at High Street,	20
Medford,	Jerome Street, at High Street,	10
Melrose,	Ravine Road, right of way to Melrose Reservoir,	20
Milton,	Adams Street, at Canton Avenue,	12
Nahant,	Beach Road, at Nahant-Lynn line,	8
Quincy,	Adams Street, at Beale Street,	24
Revere,	Prospect Avenue, at Revere Reservoir,	12
Somerville, . . .	Boston Avenue, at Professors Row,	12
Somerville, . . .	Cedar Street, at Broadway,	16
Somerville, . . .	Broadway, at Willow Avenue,	16

DISTRICT SUPPLIED BY METER.	Location of Meter.	Size of Meter (Inches).
Somerville, . . .	Medford Street, at Central Street,	12
Somerville, . . .	Pearl Street, at Walnut Street,	16
Somerville, . . .	Broadway, at Marshall Street,	12
Somerville, . . .	Webster Avenue, near Newton Street,	20
Somerville, . . .	Willow Street, at Elm Street,	16
Swampscott, . . .	Ocean Street, at Nahant Road,	12
Stoneham, . . .	High-service pumping station, Spot Pond,	24
Watertown, . . .	Mount Auburn Street, near Irving Street,	16
Winthrop, . . .	Atlantic Avenue, at Crescent Avenue,	16

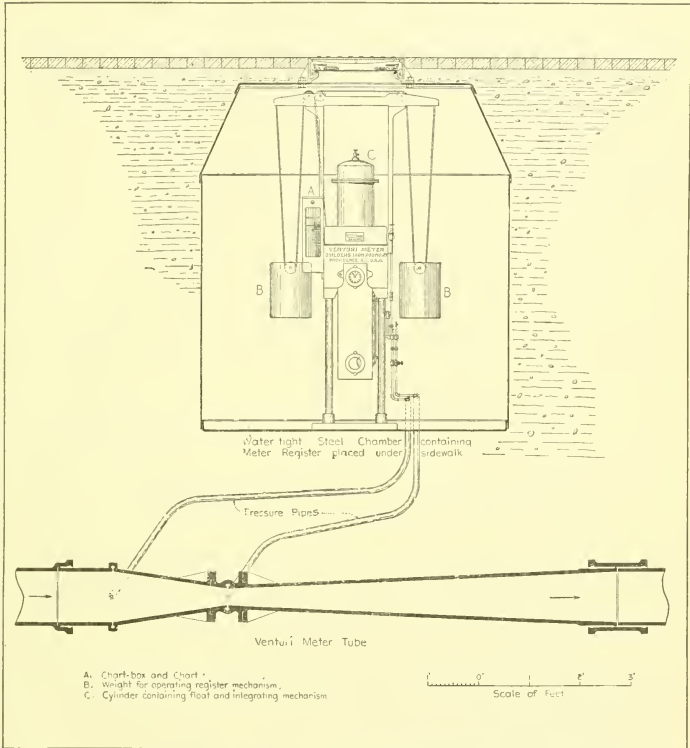
The work of setting the meters was begun in August, 1902, and continued as fast as the meters were received, until the middle of December, 1902, when the work was stopped by cold weather. It was resumed in March, 1903, and continued until June 27, when all meters required for measuring the water used in the 18 cities and towns supplied by the Metropolitan Works had been set. The cost of the work to date has been \$74,088.54. This amount does not include the cost of 2 48-inch, 1 36-inch, 1 24-inch and 2 16-inch meters purchased and set previous to the passage of the Act.

Although 24 of the meter tubes were set during the year 1902, the manufacturers did not deliver any of the registering apparatus until early in 1903; and it was not until January 24 that any of the meters purchased in 1902 were placed in service.

Continuous measurements of the consumption in the several cities and towns have been made since the following dates:—

Stoneham,	January 1	Milton,	February 28
Melrose,	January 24	Chelsea,	April 11
Medford,	February 3	Quincy,	May 8
Everett,	February 6	Nahant,	June 18
Revere,	February 13	Swampscott,	June 18
Malden,	February 16	Arlington,	June 19
Watertown,	February 16	Lexington,	June 19
Belmont,	February 20	Somerville,	June 24
Winthrop,	February 26	Boston,	June 26

The Venturi meter is entirely different in principle, design and operation from the water meters in general use for measuring water used by water takers. The meter proper consists of two truncated



VENTURI METER AND REGISTER CHAMBER.

cones of cast iron, joined at the smallest diameter by a short throat piece of cast iron lined with brass, having a diameter varying in different meters from one-quarter to one-half of the diameter of the large ends of the cones, the three parts making what is known as the meter tube. At the up-stream end and at the throat small holes are drilled into the tube, from which pipes are carried to the register. The operation of the meter is due to the fact that when

water is flowing through the tube the pressure at the throat is less than at the up-stream end, and that the difference in pressure is dependent upon the quantity of water flowing through the tube. The differing pressures at the up-stream end and throat of the meter tube are transmitted through small pipes to the register, which can be located at any convenient point within 300 or 400 feet of the tube. In the register the differences of pressure affect the level of a column of mercury which carries a float. The position of this float is thus made dependent upon the quantity of water passing through the meter; and by suitable mechanism the quantity is recorded by a counter, and the rate of flow at intervals of ten minutes is recorded upon a roll of paper, so that the fluctuations in the flow throughout each day can be observed. Although the pressure at the throat of the meter is often several pounds less than at the inlet or up-stream end, the lost pressure is nearly all regained by the time the water reaches the outlet end of the tube, so that the net loss of pressure caused by the meter is seldom more than one pound, under ordinary conditions of use.

This type of meter is well adapted for measuring large volumes of water through pipes in which the maximum rate of flow does not exceed eight or ten times the minimum rate. The smallest rate of flow recorded by the 8-inch meters is 50,000 gallons per day, and the 48-inch meters record flows at the rate of 60,000,000 gallons during the same time. Comparisons of the water used in the Metropolitan District, as determined by current meter measurements of the flow in the aqueducts, by displacement of the plungers on the pumping engines and by the Venturi meters, indicate that the meters probably give results which are accurate within 2 per cent. Facsimile copies of records made by the meters, showing the rate of consumption in some of the districts, are shown on diagram 9.

The daily average quantity of water used in each of the cities and towns during each month since June 30, 1903, is given in the following table (No. 3), and in a table appended to this report will be found the daily average for each week.

TABLE No. 3. — *Daily Average Consumption of Water in Cities and Towns supplied from Metropolitan Works as measured by Venturi Meters.*

CITY OR TOWN.	JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	Gallons per Day.	Gallons per Capita.	Gallons per Day.	Gallons per Capita.	Gallons per Day.	Gallons per Capita.	Gallons per Day.	Gallons per Capita.	Gallons per Day.	Gallons per Capita.	Gallons per Day.	Gallons per Capita.
Boston, . . .	76,616,200	128	75,322,600	125	77,172,100	128	76,815,100	128	77,201,700	128	85,284,400	141
Somerville, . .	5,944,600	88	5,357,300	79	5,630,900	83	5,424,500	79	5,267,100	77	5,863,200	85
Malden, . . .	1,883,800	51	1,764,800	48	1,913,600	51	1,742,700	47	1,620,500	43	1,653,300	44
Chelsea, . . .	3,330,000	93	3,195,900	89	3,190,300	88	3,194,700	88	3,218,200	89	4,150,200	115
Everett, . . .	2,108,800	77	2,188,200	77	2,269,100	80	2,209,200	78	2,350,800	82	2,636,700	92
Quincy, . . .	2,670,900	99	2,397,000	89	2,392,400	88	2,273,300	84	2,252,400	83	2,475,800	91
Medford, . . .	1,693,200	81	1,572,800	75	1,753,600	84	1,647,500	78	1,594,000	75	1,659,400	78
Melrose, . . .	1,469,300	105	1,403,500	100	1,442,800	103	1,414,600	101	1,341,300	95	1,304,000	93
Revere, . . .	868,500	67	859,400	63	813,100	62	704,800	53	691,700	52	824,500	62
Watertown, . .	578,100	53	549,400	50	560,400	51	525,800	48	496,600	45	480,200	44
Arlington, . .	799,700	82	640,200	65	501,900	51	554,300	56	531,300	54	567,600	57
Milton, . . .	338,500	46	335,700	45	365,500	49	319,900	43	327,900	44	272,100	36
Winthrop, . .	738,300	100	758,200	102	694,100	93	602,800	80	564,500	75	640,700	84
Stoneham, . .	483,600	76	505,600	79	458,700	72	441,700	69	445,200	70	475,600	74
Swampscott, . .	713,100	94	715,100	94	592,500	83	457,100	74	347,500	67	338,600	65
Belmont, . . .	208,800	43	229,000	47	252,100	52	243,000	50	226,100	46	215,200	44
Lexington, . .	267,800	74	278,800	78	309,000	86	233,900	65	181,200	50	185,500	50
Nahant, . . .	317,600	83	237,300	62	194,600	58	86,100	37	41,600	31	52,900	39
	101,091,800	112	98,310,800	108	100,497,700	111	98,891,000	109	98,699,600	109	109,080,500	120

The total consumption of the District, as given in the preceding table, is about $2\frac{1}{2}$ per cent. less than the consumption as measured by the displacement of the pump plungers at the pumping stations. The difference includes the quantity used in all of the pumping stations and the leakage from the Metropolitan mains and reservoirs. This use and leakage is estimated to be not less than 500,000 gallons per day.

It will be noticed that there are great differences in the per capita use in the several municipalities. To some extent these differences can be explained by the difference in the class of takers supplied; but, excepting the five larger cities, where the manufacturing and trade use is considerable, it is safe to assume that where the consumption per capita is more than 50 gallons per day the excess is wasted.

Investigations have been made to determine the amount of water used in the several municipalities for domestic purposes, for manufacturing, mechanical and trade purposes, and for public purposes; also to ascertain the various ways in which water is unnecessarily used or wasted.

USE OF WATER FOR DOMESTIC PURPOSES.

The term "domestic use" will, for the purposes of this report, be understood to include not only the strictly household use, but also the water used for private stables and watering lawns. The best information regarding the quantity used for these purposes is obtained from the records of the cities and towns where all or a large percentage of the water takers are supplied through meters. Within the Metropolitan District there are about 8,500 meters supplying water for domestic purposes. In the towns of Belmont and Milton every service pipe is metered; in Watertown, 89.5 per cent.; and in Malden, 63.4 per cent.

The average daily quantity of water used for domestic purposes as measured by meters in each of these municipalities during the years 1901 and 1902 was as follows:—

CITY OR TOWN.	NUMBER OF CONSUMERS.		GALLONS PER DAY.		GALLONS PER DAY PER CONSUMER.	
	1901.	1902.	1901.	1902.	1901.	1902.
Belmont,	3,600	3,900	63,760	66,630	17.7	17.1
Malden,	21,100	22,550	414,030	450,160	19.6	20.0
Milton,	6,850	7,450	115,000	143,500	16.8	19.3
Watertown,	9,650	10,250	147,200	152,900	15.3	14.8
	41,200	44,150	739,990	813,190	18.0	18.4

The above quantities include water used for stables supplied in connection with dwellings and that used for lawn sprinkling, as well as that used strictly for household purposes. In all these municipalities the meters have been in use but a comparatively few years, and it is not probable that they have become worn so as to cause a large percentage of error in registration. The experience in other cities and towns where meters are in general use on domestic services corroborates the results obtained in the Metropolitan District.

Table No. 4 gives the per capita metered consumption for the year 1902 in several places where all or a large percentage of the water used is metered.

TABLE NO. 4.

CITY OR TOWN.	Estimated Number of Consumers.	Per Cent. of Services metered.	Total Daily Average Metered Consumption (Gallons).	GALLONS PER CONSUMER PER DAY		
				Domestic.	Manufacturing.	Totals.
Brockton,	37,800	90.0	822,670	13.2	6.5	* 21.8
Fall River,	107,650	96.0	2,607,100	15.5	5.2	* 22.2
Newton,	35,400	86.0	1,202,740	23.1	4.6	* 34.0
Ware,	7,690	100.0	203,430	25.4	1.1	26.5
Woonsocket, R. I.,	34,474	86.7	762,380	11.6	10.5	22.1
Wellesley,	5,147	100.0	132,540	25.6	.1	25.7
Worcester,	119,330	94.5	4,331,030	16.1	17.8	* 36.3
Yonkers, N. Y.,	51,000	98.7	2,413,380	19.7	22.0	* 42.7
	398,491	-	12,475,270	16.7	-	-

* Includes water used for public purposes.

The statement sometimes made that the greatest use or waste of water is to be found in the cheapest class of houses is not substantiated by the results obtained where water is supplied by meter. On the contrary, experience seems to indicate that the per capita

use of water for domestic purposes increases with the value of the property supplied.

This is illustrated by the following tables (Nos. 5 and 6), the first of which gives the per capita consumption in tenement houses in the city of Boston during the year 1902, and the second the per capita consumption in houses of differing value in other cities :—

TABLE NO. 5. — *Use of Water in Tenement Houses in Boston during 1902.*

WARD.	Number of Houses.	Number of Families.	Number of Persons.	GALLONS PER DAY.		Monthly Rental.
				Per Family.	Per Capita.	
Ward 6,	21	263	1,226	115	24.8	\$12 to \$16
Ward 7,	8	75	365	71	14.5	12 to 16
Ward 7,	13	155	755	64	13.2	16 to 20
Ward 8,	15	131	625	113	23.7	16 to 20
Ward 9,	20	171	758	92	20.7	12 to 20
Ward 8,	12	116	553	141	29.6	20 to 25
Ward 8,	10	88	420	138	29.0	25 to 30
Ward 10,	21	209	949	150	33.1	25 to 30
Ward 10,	20	250	1,135	200	43.9	30 to 40
Ward 11,	10	111	545	190	38.7	25 to 45
Ward 11,	10	89	437	194	39.5	35 to 55
Ward 11,	9	81	368	218	44.4	50 upwards
	169	1,739	8,166	139	29.63	-

TABLE NO. 6. — *Domestic Consumption per Capita in Newton, Fall River, Worcester and London, Eng., as determined by Meter Measurement.*

CITY OR TOWN.	Number of Houses.	Number of Families.	Number of Persons.	CONSUMPTION (GALLONS).		Remarks.
				Per Family.	Per Capita.	
Newton,	490	490	2,450	132.5	26.5	All houses supplied with modern plumbing.
Newton,	-	619	3,005	-	6.6	These families have but one faucet each.
Newton,	-	278	1,390	34.5	6.9	These families have but one faucet each.
Fall River,	28	34	170	127.5	25.5	The most expensive houses in the city.
Fall River,	64	148	740	42.0	8.4	Average class of houses, generally having bath and water-closet.
Worcester,	-	81	327	80.2	19.9	Woodland Street, best class of houses.
Worcester,	-	37	187	118.1	23.4	Cedar Street, best class of houses.
Worcester,	-	93	447	95.0	19.8	Elm Street, houses of moderate cost.
Worcester,	-	245	1,104	55.1	12.2	Southbridge Street, cheaper houses
Worcester,	-	229	809	55.0	15.6	Austin Street, cheaper houses.
London, Eng.,	1,169	-	8,183	-	25.5	Houses renting from \$250 to \$600; each have bath and two water closets.
London, Eng.,	727	-	5,089	-	18.6	Middle class, average rental, \$200.

During the past thirty years the number of water fixtures has increased much faster than the population. In Boston, for example, the average number of fixtures per capita increased from .523 in 1870 to 1.165 in 1900, so that the opportunities for the use and waste of water were greatly increased. It is probable that there is likely to be still further increase in the use of water for domestic purposes, even though it be supplied and paid for by meter measurement; but it does not seem probable that the quantity needed will exceed 25 gallons per capita for many years to come.

USE OF WATER FOR MANUFACTURING, MECHANICAL AND TRADE PURPOSES.

The use of water for manufacturing, mechanical and trade purposes varies to a wide degree in different municipalities, depending upon the extent of business and trade and upon the character of the purposes for which water is used. The manufacturing and trade use in the Metropolitan Water District is centered in Boston, although the per capita use for these purposes is quite large in several other cities and towns.

The greater portion of the water used for manufacturing and trade in the Metropolitan District is supplied through meters, and the metered use in the several municipalities for these purposes during the year 1902 was as follows:—

TABLE No. 7. — *Water supplied through Meters for Manufacturing, Mechanical and Trade Purposes, during the Year 1902.*
 [Gallons per capita per day.]

	Boston.	Somerville.	Chelsea.	Malden.	Beverly.	Quincy.	Medford.	Melrose.	Revere.	Watertown.	Arlington.	Milton.	Winthrop.	Stoneham.	Belmont.	Lexington.	Nahant.	Swampscott.	Metropolitan District.
Bakeries, . . . . .	.07	.06	.18	—	.04	—	—	.03	—	—	—	—	—	—	—	—	—	—	.06
Breweries and bottling, . . . . .	.96	.10	—	—	.04	—	—	—	—	—	—	—	—	—	—	—	—	—	.65
Electric companies,	1.73	.62	—	1.40	—	.31	—	.07	1.42	—	—	—	—	—	—	—	—	—	1.29
Elevators and motors,	1.70	.09	.04	.08	.02	.08	.08	.07	.01	—	—	.04	.03	—	.03	.58	—	—	1.16
Factories and machine shops,	2.10	.73	6.15	.85	.37	2.03	.48	.19	—	1.91	.09	—	—	1.74	—	—	—	—	1.86
Farms and greenhouses, . . . . .	.04	.02	—	.04	—	.02	.02	.16	.10	1.06	4.12	.01	—	.23	4.76	.28	—	—	.12
Gas works, . . . . .	.31	—	.05	.11	13.46	.06	.08	.16	.16	—	.23	—	—	—	—	—	—	—	.63
Hotels,	2.70	.07	.13	.08	—	.06	—	—	—	—	.18	—	—	—	—	—	—	—	1.83
Iron works, . . . . .	.29	.01	.35	—	1.22	—	.29	.08	—	—	—	.02	—	—	—	—	—	—	.25
Laundries, . . . . .	.41	—	.12	.01	.03	—	.28	.63	.19	.64	.41	.07	—	—	.03	—	—	—	.29
Offices and stores,	5.12	.39	.12	.70	.23	—	.68	.04	—	—	.02	—	—	—	—	—	—	—	3.53
Oil and chemicals,	5.12	.16	.06	.06	2.61	—	—	—	—	.66	.67	.01	—	—	—	—	—	—	.19
Railways,	5.62	5.63	2.62	.04	.04	—	1.03	.17	—	—	—	—	—	1.17	.19	1.07	—	—	4.35
Restaurants and saloons, . . . . .	.85	—	—	—	.11	.10	—	—	—	—	—	—	—	—	—	.10	—	—	.57
Shipping, . . . . .	.77	.10	1.25	.06	—	—	—	—	—	—	—	—	—	—	—	—	.27	—	.57
Slaughtering, . . . . .	.09	6.35	—	—	—	.01	.15	.45	—	—	—	.36	—	—	.05	—	—	—	.46
Stables, . . . . .	.59	.48	1.27	.15	.19	—	—	—	—	—	—	—	—	.18	—	—	1.21	—	.51
Sugar refineries,	1.12	—	—	—	—	2.32	—	—	—	—	—	—	—	—	—	—	—	—	.82
Miscellaneous, . . . . .	.30	.11	.01	.35	.22	1.58	.45	—	.19	—	.38	4.07	.14	—	—	—	—	—	.33
Totals,	24.90	13.98	12.38	3.93	13.61	6.72	3.89	1.54	1.88	4.27	6.11	4.69	.17	3.34	5.06	2.52	1.58	—	19.47

Careful estimates of the quantity of water used for these purposes, which is not metered, indicate that the amount is not more than 5 gallons per capita in Boston and from 2 to 3 gallons per capita in other cities and towns in the District, with an average of about 4 gallons for the whole District. This quantity, added to the quantity supplied through meters, gives about 23.5 gallons per capita per day required at the present time for manufacturing, mechanical and trade purposes in the Metropolitan Water District.

In other cities of the United States there exists a wide difference in the amount of water used from the public water supplies for manufacturing and mechanical purposes, depending upon the character of the manufacturing carried on or the rates charged for water, and upon other local conditions.

The following table (No. 8) gives the total metered consumption in 1902 in several of the largest cities of the United States, where very little or none of the water supplied for domestic use is metered: —

TABLE No. 8.

CITIES.	Number of Meters.	Daily Average Metered Consumption (Gallons).	Per Cent. of Services metered.	Gallons per Capita.	Gallons per Metered Service per Day.
Boston,	5,381	17,521,400	6.03	29.90	3,393
St. Louis, Mo.,	4,635	15,149,000	6.41	23.30	3,495
Baltimore, Md.,	2,182	13,226,000	2.17	25.20	6,061
Buffalo, N. Y.,	1,375	16,501,800	2.04	46.00	12,000
Pittsburg, Pa.,	394	4,279,000	1.09	16.40	10,860
Detroit, Mich.,	5,847	14,970,800	9.24	42.70	2,543
Chicago, Ill.,	7,075	41,096,000	2.18	18.30	5,809
Philadelphia, Pa.,	1,510	16,430,400	.59	12.20	10,881

In the city of Buffalo the water rates are very low, and the use of water for manufacturing and mechanical purposes is very large. From 2.04 per cent., or about one-fiftieth of the service pipes in use, there are drawn daily 16,501,800 gallons, — an amount equivalent to 46 gallons per inhabitant for the whole city. This per capita quantity used by a comparatively few water takers is 8 gallons more than the per capita consumption in the city of Fall River for all purposes, domestic, manufacturing and public. In Fall River the use of water from the public water supply for manufacturing and trade

purposes is only 5 gallons per capita, the factories obtaining their supply of water from a stream which flows through the city.

A comparison of the figures giving the percentage of services metered and the daily number of gallons used per meter and per capita indicates that but a small portion of the total manufacturing, mechanical and trade uses are metered in several of the cities, and that the total use for these purposes is much larger than in the Metropolitan District.

USE OF WATER FOR PUBLIC PURPOSES.

The principal uses included under this head are for public buildings, for public fountains, for sprinkling streets, for flushing water pipes and sewers, and for extinguishing fires.

While the quantity used for public purposes in most cities is a very small proportion of the total quantity used, there is a large difference in the quantity used in different cities, and in some instances the public use is quite a large proportion of the total. Where no charge is made for water used in public buildings and for other public uses, it often happens that little or no attention is given by the officials in charge to prevent the extravagant use or waste of water, and for this reason the quantity used is sometimes very large. In the several municipalities comprising the Metropolitan Water District the practice regarding payment for water used for public purposes is not at all uniform. In Boston, Somerville, Quincy, Melrose, Watertown, Arlington and Stoneham the water departments receive no income from water furnished to other departments of the municipality; but in Watertown, Quincy and Stoneham the income from water rents is insufficient to pay the maintenance, interest and sinking fund requirements, and a sum to meet the deficiency is raised by general taxation. In Chelsea, Revere, Milton, Winthrop, Lexington and Nahant the water departments receive an income for water used for all public purposes, including a payment for fire hydrants. In Malden, Everett and Belmont an income is received for water used in public buildings, but no charge is made for fire hydrants or for water used in sprinkling streets and flushing sewers. In Medford an income is received for water used in public buildings and for fire hydrants, but not for street sprinkling and flushing sewers.

Public Buildings.

Under the head of public buildings are included schools, fire engine houses, State House, city and town halls, hospitals, asylums and jails, churches and theatres, and all other national, State, county and municipal buildings.

The best measurement of the quantity required for public schools is that furnished by the records in several of the cities and towns where the water furnished to the schools has been metered. The results of these measurements are given in the following table (No. 9) :—

TABLE NO. 9. — *Use of Water in Schools.*

CITY OR TOWN.	Year.	Number of Schools metered.	Teachers and Scholars in Schools metered.	Total Teachers and Scholars in City.	Gallons per Scholar per School Day.*	Gallons per Day per Inhabitant for Schools.	Remarks.
Boston, . .	1899	†-	72,190	72,190	6.22	.41	All metered except about 7 per cent.
Malden, . .	1901	17	5,446	5,446	2.21	.17	
Malden, . .	1902	18	5,640	5,640	2.26	.18	
Medford, . .	1901	13	2,734	3,214	4.02	.33	
Medford, . .	1902	13	2,874	3,354	4.11	.34	
Belmont, . .	1902	4	626	626	6.96	.48	
Milton, . .	1901	6	1,122	1,122	6.56	.53	One school of 70 scholars does not use city water, and is not metered.
Somerville, .	1899	22	9,004	9,228	6.29	.46	All except one school metered.

* This column is based on the assumption that there are 180 school days in the year.

† The quantity used was metered, except about 7 per cent., which was estimated from the amount received from annual rates at 14 cents per 100 cubic feet. The number of scholars in the unmetered schools could not be readily ascertained.

The use for public schools should not exceed .5 of a gallon per capita of the total population. The private schools and colleges in the Metropolitan District used by meter measurement, in the year 1902, a quantity equivalent to .2 of a gallon per capita of the entire population, which, added to the public school use, gives .7 of a gallon for the total use of schools.

During the year 1902 the water used through meters in the national, State and county buildings in the District, including the use at the Navy Yard and the Watertown Arsenal, was equivalent to .58 of a gallon per capita; and the quantity supplied through meters to the

hospitals, asylums, jails and prisons was equivalent to .5 of a gallon per capita. In Boston the water supplied to the public institutions on Deer, Long, Rainsford and Gallops islands, the city hospital, the insane asylum, city hall, fire engine houses and other municipal buildings is not metered, neither is that supplied to public buildings in several other cities and towns. This unmetered quantity is estimated at 1.5 gallons per capita of the total population.

In churches, theatres, clubs and public halls the quantity used in 1902 by meter measurement was equivalent to .4 of a gallon per capita, and it is probable that at least .1 of a gallon was used which was not metered, making the use for these purposes .5 of a gallon per capita per day.

The total for public buildings is as follows: —

	Gallons.
Schools, . . . . .	.70
National, State and county buildings, metered, . . . . .	.58
Hospitals, asylums and jails, metered, . . . . .	.50
Churches, theatres and clubs, metered, . . . . .	.40
Public buildings, other than schools, unmetered,	1.60
Total for public buildings,	3.78

Public Fountains.

The estimated quantity of water used by 139 public drinking fountains, which are located in the several cities and towns supplied by the Metropolitan Works, averages 664,640 gallons per day, equivalent to .74 of a gallon per capita of the population supplied.

The following table (No. 10) shows the estimated quantities used in the several cities and towns: —

TABLE NO. 10.

CITY OR TOWN.	Number of Public Drinking Fountains.	Estimated Daily Average Quantity used (Gallons).	CITY OR TOWN.	Number of Public Drinking Fountains.	Estimated Daily Average Quantity used (Gallons).
Arlington,	4	10,120	Nahant,	3	9,030
Belmont,	2	11,230	Quincy,	9	34,060
Boston,	62	380,900	Revere,	4	16,040
Chelsea,	2	17,240	Somerville,	6	33,410
Everett,	3	16,670	Stoneham,	1	1,560
Lexington,	3	10,490	Swampscott,	4	11,810
Malden,	11	48,460	Watertown,	4	5,500
Medford,	10	32,280	Winthrop,	4	13,770
Melrose,	4	8,810			
Milton,	3	3,260	Total,	139	664,640

In the greater proportion of the drinking fountains the water runs continuously, and it follows that the greater part of the water is wasted. The average use in 18 fountains of this class in Boston, as determined by measurement, was 14,000 gallons per day each. Thirty-three of the drinking fountains for animals used in Boston are so arranged that during the six summer months the flow into the trough is controlled by an automatic valve, and no water is wasted; during the winter season the flow is continuous. Meters attached to two of these fountains showed that the use during the summer was at the rate of 1,250 gallons per day, and during the winter, when less water is needed, 6,250 gallons, or five times the summer use.

In the city of Boston there are 20 ornamental playing fountains, located on the Common, public gardens and public squares, nearly all of which are allowed to run continuously during six months of the year. The quantity discharged by these fountains has been measured where practicable, and the total quantity is estimated to be 237,000 gallons per day for six months, equivalent to .2 of a gallon per capita for the whole year. The combined use for drinking and ornamental fountains is about 1 gallon per capita per day.

Street Sprinkling.

For sprinkling streets throughout the Metropolitan District in the year 1901 the quantity used is estimated to have been nearly 700,000,000 gallons, equivalent to 2.13 gallons per capita per day for the year.

TABLE NO. 11. — *Water used for sprinkling Streets in the Metropolitan District, 1901.*

CITY OR TOWN.	Total Gallons.	Gallons per Square Yard of watered Street, per Year.	Gallons per Capita per Day.	Average Width (Feet).	Length of Street watered (Miles).	Basis of Estimates.
Arlington, .	6,960,000	44.1	2.12	35.0	7.69	Estimated by town engineer and superintendent of streets.
Belmont, . .	2,250,000	18.8	1.47	30.0	6.82	Estimated by superintendent of streets.
Boston, . .	492,046,200	* 51.0	2.35	* 31.9	* 476.00	Record kept by cart-loads.
Chelsea, . .	14,198,600	42.9	1.12	27.0	18.14	Record kept by cart-loads.
Everett, . .	18,214,800	44.9	1.87	28.8	23.91	Estimated by superintendent of Board of Public Works.
Malden, . .	23,664,900	54.0	1.87	31.1	24.05	Record kept by cart-loads.
Medford, . .	23,795,900	51.5	3.41	28.2	27.96	Estimated from data furnished by street department.
Melrose, . .	10,000,000	38.8	2.06	27.0	16.22	Estimated by superintendent of Public Works.
Milton, . .	14,559,900	27.5	5.87	21.2	42.57	All metered at stand-pipes.
Nabant, . .	3,784,000	21.6	8.63	24.0	12.45	Estimated by superintendent of streets.
Quincy, . .	12,960,000	57.0	1.43	26.0	14.90	Estimated by commissioner of Public Works.
Revere, . .	3,942,500	19.7	.96	31.4	10.88	Record kept by cart-loads.
Somerville, .	45,780,300	60.5	1.97	24.3	53.02	Estimated by street department.
Stoneham, .	1,400,000	31.8	.60	37.5	2.00	Estimated by water department.
Swampscott, .	6,292,800	36.7	3.67	28.4	10.26	Estimated by superintendent of Water Works.
Watertown, .	13,450,000	51.6	3.67	39.3	11.33	Estimated by superintendent of streets.
Winthrop, .	5,900,600	19.2	2.48	25.8	20.28	Record kept by cart-loads.
	699,200,500	48.1	2.13	30.1	778.48	

Total square yards, 13,754,700.

* Length of sprinkled roadways in Boston park system not known, and so not included with these figures. The amount of water used for this purpose was 37,500,000 gallons, and this is included in the other two columns.

The quantity used in the several municipalities has been determined from the best data obtainable. In the town of Milton the water was measured by meter at each standpipe: in Boston, Chelsea, Malden, Revere and Winthrop a record was kept of the number of loads used and the capacity of the carts; in other municipalities the quantity used has been estimated by the department officials; and, while there are doubtless inaccuracies in some of the items, it is thought that the total is fairly correct.

Flushing Water Pipes and Sewers and extinguishing Fires.

Very little information is available from which to estimate the quantity used for flushing water pipes and sewers and extinguishing fires. Although large quantities of water are at times drawn from the pipes for extinguishing fires and for flushing water pipes, the use continues for but a short time, and the total use during the year is comparatively small; the per capita yearly use probably does not exceed .20 of a gallon.

The quantity required for public purposes may be summarized as follows:—

	Gallons per Capita.
Public buildings,	3.78
Drinking and ornamental fountains,	1.00
Street sprinkling,	2.13
Flushing water pipes and sewers and extinguishing fires, . . . . .	.20
	<hr/> 7.11

QUANTITY ACTUALLY NEEDED FOR ALL PURPOSES.

From the preceding statements the total quantity actually required for legitimate use in the Metropolitan Water District at the present time is shown to be less than 60 gallons per inhabitant per day, divided as follows:—

	Gallons.
Domestic use,	25.0
Manufacturing, mechanical and trade use,	23.5
Public use,	7.0
	<hr/> 55.5

QUANTITY OF WATER WASTED.

If, as has been stated, the actual requirements for domestic, manufacturing, trade and public purposes in the Metropolitan District do not exceed 60 gallons per inhabitant, while the total supplied to the District is nearly 120 gallons, it is evident that one-half of the water furnished must be wasted either from the street mains and service pipes, or from the water fixtures and piping on the premises of the water takers. A strong proof of the existence of waste is shown by measurements of the water used between 1 and 4 A.M., when the legitimate use of water is at its minimum.

The following table (No. 12) gives the results of continuous measurements of the water used in each of the cities and towns sup-

plied by the Metropolitan Works for the period of six months, from June 28, 1903, to January 2, 1904, and shows not only the daily average quantity used, but also the rate of use between the hours of 1 and 4 A.M. : —

TABLE NO. 12. — *Daily Average (24 Hours) and Night Rate of Consumption from Metropolitan Works, June 28, 1903, to January 2, 1904.*

CITY OR TOWN.	Service.	Estimated Population.	Average Daily Consumption (Gallons).	Average Daily per Capita (Gallons).	Average Night Rate 1 to 4 A.M. (Gallons per 24 Hours).	Night Rate per Capita (Gallons per 24 Hours).
Arlington,	{ High,	3,005	252,000	84	* 200,000	67
	{ Low,	6,840	367,000	54	* 225,000	33
	{ Total,	9,845	619,000	63	425,000	43
Belmont,	High,	4,875	228,000	47	111,000	23
Boston,	{ High,	199,750	24,763,000	124	17,259,000	86
	{ Low,	402,425	53,465,000	133	37,846,000	94
	{ Total,	602,175	78,228,000	130	55,105,000	92
Chelsea,	{ High,	7,480	537,000	72	352,000	47
	{ Low,	28,645	2,862,000	100	2,005,000	70
	{ Total,	36,125	3,399,000	94	2,357,000	65
Everett,	{ High,	7,255	370,000	51	220,000	30
	{ Low,	21,195	1,937,000	91	1,332,000	63
	{ Total,	28,450	2,307,000	81	1,552,000	55
Lexington,	High,	3,600	243,000	68	* 135,000	38
Malden,	{ High,	8,985	493,000	55	278,000	31
	{ Low,	28,320	1,271,000	45	647,000	23
	{ Total,	37,315	1,764,000	47	925,000	25
Medford,	{ High,	4,030	454,000	113	318,000	79
	{ Low,	17,005	1,200,000	71	680,000	40
	{ Total,	21,035	1,654,000	78	998,000	48
Melrose,	High,	14,015	1,395,000	100	1,000,000	71
Milton,	High,	7,475	325,000	44	115,000	15
Nahant,	High,	† 2,555	159,000	62	* 50,000	20
Quincy,	High,	27,135	2,415,000	89	1,554,000	57
Revere,	High,	13,165	796,000	60	494,000	38
Somerville,	{ High,	15,985	1,152,000	72	605,000	38
	{ Low,	52,325	4,448,000	85	2,811,000	64
	{ Total,	68,310	5,600,000	82	3,416,000	50
Stoneham,	High,	6,400	467,000	73	322,000	50
Swampscott,	High,	† 6,380	527,000	83	* 260,000	41
Watertown,	High,	10,950	532,000	49	217,000	20
Winthrop,	High,	7,485	668,000	89	414,000	55
District totals,	{ High,	350,535	35,775,000	102	23,904,000	68
	{ Low,	556,755	65,550,000	118	45,546,000	82
Totals,		907,290	101,325,000	112	69,450,000	77

* Estimated.

† Allowance made for transient population during summer months.

It will be noticed that both the daily per capita and night rates of consumption vary widely in different districts, even where the takers are of the same general class. Where the rate for twenty-four hours is large, the night rate is in almost every case excessive. It is also noticeable that the lowest rates of consumption are to be found in those districts where water meters are in general use. Take, for example, the rates of consumption during the night in Milton, Watertown, Belmont and Malden, as compared with those in Medford, Melrose, Winthrop and the high-service districts of Brighton and Chelsea. The population of each of these groups is about 60,000. They are districts in which the manufacturing use is very small, and there appears to be no good reason why the legitimate use of water between the hours of 1 and 4 A.M. should not be very small in every case. In the first group the rate varies from 13.4 to 25.5 gallons per capita, with an average of 18 gallons; while in the second group it varies from 43 to 71.4 gallons, with an average of 58.3 gallons. The difference between 18 and 58 gallons is unquestionably preventable waste.

In districts where the use for manufacturing, mechanical and trade purposes is large, the legitimate use during the night is in some instances also large. Water is used in considerable quantities during the night, as well as the day, in electric light and power stations, gas works, hotels and large institutions. For example, at the New England Gas and Coke Works in Everett water is used between the hours of 1 and 4 A.M. at the rate of 500,000 gallons per day, which is equivalent to 18.5 gallons per capita per day for the entire population of the city. This, however, is an exceptional case. Considering the whole Metropolitan District, the legitimate draft during the night is very small, when compared with 77 gallons per capita, which was the average minimum rate during the last six months of the year 1903. Nearly all of the water used for manufacturing, mechanical and trade purposes is metered, and the total is but 23.5 gallons per capita, of which the greater part must be used during the day. It is not probable that the legitimate use for all purposes during the hours of minimum consumption is more than 17 gallons per capita, in which case the difference between 77 gallons drawn from the pipes and 17 gallons used, or 60 gallons, must be wasted. This amount agrees very closely with the amount obtained

by subtracting the total quantity estimated as actually required for all purposes in the Metropolitan District from the total quantity used.

Diagram No. 1 shows graphically the comparative volume of water used and wasted in the several municipalities, the cities and towns being arranged in order of per capita use. The unshaded areas at the top of the diagram show the estimated volume legitimately used, and the shaded areas at the bottom of the diagram the volume wasted. The dotted lines show the minimum rate of use, and the areas between the dotted lines and the shaded areas show the estimated use during the hours of minimum consumption.

Diagram No. 2 shows the rate of consumption in the whole district supplied by the Metropolitan Works for each hour during three weeks, as measured by Venturi meters. During the week ending July 11, 1903, the weather was hot and dry, especially during the latter part of the week; during the week ending August 8 the weather was comparatively cool, with showers and little sunshine; and during the week ending January 9, 1904, was extremely cold. On Monday, July 6, .42 of an inch of rain fell, making street sprinkling unnecessary until Tuesday afternoon. For this reason the use during Monday, July 6, was very nearly the same as on Monday, August 3. During the last four days of the week ending July 11 the maximum temperature was from 89 to 95 degrees, and a large amount of water was used for sprinkling streets and lawns. The consumption for these days was from 14,000,000 to 17,000,000 gallons per day more than during the corresponding days of the week ending August 8, when frequent showers and cool weather made both street and lawn sprinkling unnecessary. During both of these weeks the minimum rate of use was about 75 gallons per capita. The dotted upper line on the diagram shows the use during a week of very cold weather.

CAUSES OF WASTE.

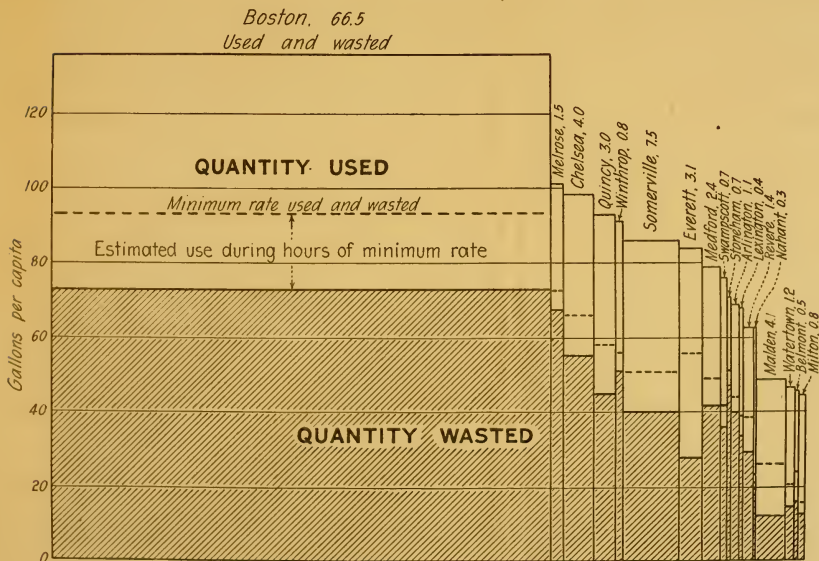
Water is wasted, either negligently or wilfully, from mains and service pipes in the public streets, or from pipes and fixtures on the premises of the water takers.

Waste from Street Mains and Services.

The amount wasted from the street mains and service pipes is a much larger percentage of the total consumption than has been

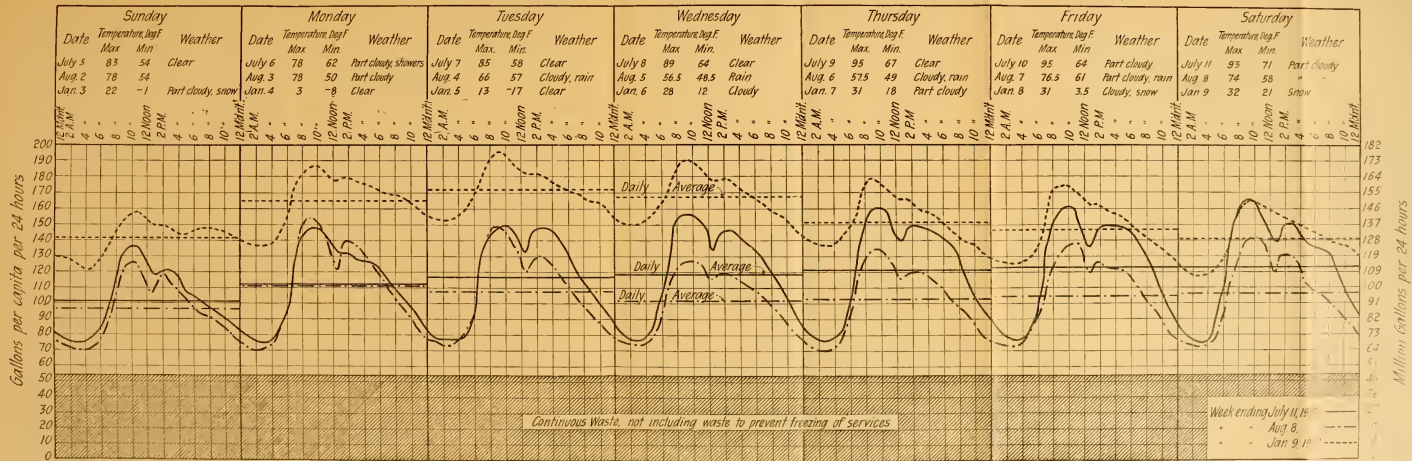
Diagram showing the per capita quantity of water used and wasted in the several cities and towns supplied by the Metropolitan Water Works.

Figures following names of cities and towns show percentage of total population of district



Hourly Variation in the Consumption of Water in the Metropolitan District. (From Venturi Meter Records, 1903-4.)

Diagram No.2



generally estimated. This fact is proved by the results obtained where water supplied to individual takers is measured, and can be compared with the total quantity supplied to the city or town. In the Metropolitan District in the town of Milton the water supplied to every taker is metered, including that used for street watering and other public purposes. In Belmont all supplies are metered, and a careful record is kept of the number of loads of water used for street watering. The total quantity of water delivered into the pipes of each town has been measured by means of Venturi meters, and, if the meters through which water is supplied to individual takers record accurately the water passing through them, the difference between the quantity recorded by the local meters and that delivered into the pipes of the town must represent the leakage from the street mains and service pipes.

The results of the observations made in these towns are as follows : —

TOWNS.	GALLONS PER DAY.			Per Cent. unac- counted for.	Gallons per Day un- accounted for per Mile of Pipe.
	Delivered into Pipes of Town.	Metered to Consumer.	Unac- counted for.		
Milton, April, May, June,	325,100	216,300	108,800	33.5	3,110
Milton, July, August, September, . .	328,000	199,100	128,900	39.3	3,680
Belmont, March 15 to May 15, . . .	171,500	135,300	36,200	21.1	2,130
Belmont, May 15 to September 15, . .	230,500	145,000	85,500	37.1	4,780

In both of these towns meters have been used but a few years, and it does not seem probable that the loss in registration of the meters can be more than 2 or 3 per cent.

Similar results have been obtained in every city and town where the water supply to individual takers has been metered. In the following cities and towns meters are in use on all or a very large percentage of the services, but in every case a large percentage of the water delivered into the mains from the reservoir or pumps is unaccounted for by the meters.

TABLE NO. 13.

CITY OR TOWN.	DELIVERED INTO MAINS.			METERED TO CONSUMERS, OR OTHERWISE ACCOUNTED FOR.		Per Cent. un- accounted for.	Gallons per Day un- accounted for per Mile of Pipe.
	Per Cent. of Taps metered.	Daily Average (Gallons).	Gallons per Consumer.	Gallons.	Gallons per Consumer.		
Brockton, . .	90.0	1,362,470	36.0	902,120	22.0	32.3	6,200
Ware, . .	100.0	338,160	44.0	203,430	26.5	39.8	11,200
Worcester, . .	94.5	8,094,840	68.0	4,331,030	39.0	46.5	20,800
Wellesley, . .	100.0	257,000	50.0	150,000	29.0	41.5	3,450
Yonkers, N. Y.,	100.0	4,540,900	89.0	2,463,490	42.7	45.7	23,340
Fall River, . .	96.0	4,365,060	40.5	3,430,300	32.0	21.5	10,000
Woonsocket, R. I.	86.7	989,420	28.6	762,380	22.0	23.0	4,370

In Belmont and Milton the quantity unaccounted for by the house meters varied from 2,130 to 4,780 gallons per mile of pipe per day, while in the cities and towns given in the above table the corresponding quantities vary from 3,450 to over 23,000 gallons. It is possible that in some instances the quantity delivered into the mains is overestimated, but there is no doubt that in the majority of cities there is a large leakage from mains and services. The opportunities for leakage from pipes buried underground are great, and the chances for their discovery are in most cases comparatively small. In the Metropolitan Water District there are 1,457 miles of pipes, on which there are 750,000 leaded joints from which leakage may occur. Leaks of considerable magnitude often remain undiscovered for months, the water escaping into the ground or into a brook or sewer. Several years ago, while Deacon waste-water meters were being used in Boston to detect leaks, several 4-inch and 6-inch cast-iron pipes were found broken, from which the water was escaping unseen into the sewers. In a number of instances this leakage was at the rate of 24,000 gallons per day, and in one instance 100,000 gallons per day were found to be running into a sewer from a 6-inch pipe which was broken entirely off.

A very forcible illustration of this source of waste has been furnished in the town of Stoneham. During the first six months of the year 1902 about 800,000 gallons per day were supplied to the town. As this quantity appeared larger than was needed for legitimate use, an investigation was instituted for the purpose of learning where the

water was used, with the result that four leaks in the street mains were found, which gave no surface indications. After these were repaired the consumption of water fell to 330,000 gallons per day, indicating that 470,000 gallons per day had been wasting from a few unseen defective pipes.

On the Boston works several large leaks in mains and service pipes have been discovered during the past year by means of the Deacon waste-water meters. The aggregate waste from eight of these was about 27,000 gallons per hour, equivalent to 648,000 gallons per day. In Arlington, Chelsea and Medford leaks from defective joints in the street mains have been discovered from which water was wasting at rates of from 1,000 to 2,000 gallons per hour, without any indications being given on the surface.

Tests have been made in Melrose to determine the amount of water leaking from the mains and services, by measuring with a meter the rate of flow into the pipe supplying certain streets while all the stop cocks on the house services were closed. These tests were made during the night, when the legitimate use was very small. The result of these measurements was as follows:—

TABLE NO. 14.

LENGTH OF MAIN	Size (Inches).	Number of Service Pipes.	Leakage from Mains (Gallons per Hour).	Leakage and Use in Houses (Gallons per Hour).
1,000 feet,	6	20	1,035	180
600 feet,	6	13	250	290
1,000 feet,	6	22	225	70
400 feet,	6	10	675	45
500 feet,	6	9	-	25
1,150 feet,	4	21	1,080	270
350 feet,	-	8	-	90
700 feet,	6	14	-	180
1,550 feet,	6	21	180	520
1,000 feet,	-	22	-	270
600 feet,	8	12	-	180
1,250 feet,	14	33	45	270

The total leakage from less than 2 miles of pipes was 3,490 gallons per hour, or at the rate of 43,770 gallons per mile of pipe per day.

If, as has been shown by numerous examples, from 50,000 to 100,000 gallons of water per day can run into the ground continuously for months from a single leak in a main or service pipe, and give no indication on the surface of the ground, it is reasonable to conclude that there are, on the 750,000 joints in the street mains and the 150,000 service pipes, many smaller leaks, which, being smaller, are not easily discovered, but which in the aggregate waste a large quantity of water. Some water is wasted from street mains through carelessness in the manipulation of blow-off gates by department employ  s, and by the extravagant use of water for flushing sewers. Several years ago a blow-off valve was carelessly left open in Boston, and water ran for several days into a sewer at the rate of 3,000,000 gallons per day. In flushing water pipes and sewers much larger quantities are often used than are necessary for accomplishing the results desired, but it is not thought that the aggregate amount wasted in this way is large.

The tests which have been made in the several municipalities of the Metropolitan District tend to show that the leakage from the street mains and services is very large, and that from 10,000 to 15,000 gallons per mile of street main escape each day into the ground or into some underground channel. If this estimate is correct, the total leakage from the mains and services is from 15,000,000 to 22,500,000 gallons per day, — equivalent to from 16.5 to 25 gallons per inhabitant.

Waste from Pipes and Fixtures on Premises of Water Takers.

Waste from pipes or fixtures on premises of water takers is due either to defective plumbing or to permitting the water to run from open fixtures, either negligently or wilfully. Where the amount paid for water is not dependent upon the quantity of water used, the average water taker pays little attention to the condition of the plumbing on his premises; and, so long as the leaking fixtures cause no damage to his property, they are seldom repaired unless discovered by inspectors of the Water Department. For this reason the amount of waste from defective fixtures in cities where meters are not used depends largely upon the thoroughness with which the house-to-house inspection is done by the local authorities.

The greatest source of negligent waste from defective fixtures is undoubtedly the ball cock which controls the flow of water into

tanks supplying water-closets and other fixtures. The ball cock seldom remains tight more than a few months, and when defective allows a constant stream of water, often of considerable size, to flow unseen, though not always unheard, to the sewer. Although the ball cock is more liable than any other plumbing fixture to be the cause of waste, its inspection is more difficult than that of other fixtures, the tanks being generally placed in inaccessible places in buildings. Unless the inspection is very thoroughly performed, the greatest source of this kind of waste is therefore apt to be overlooked. Nevertheless, more tank fixtures are reported defective than any other class.

The following figures, taken from the annual reports of the Boston Water Department, show the results of inspections made during the past seven years:—

	1897.	1898.	1899.	1900.	1901.	1902.	1903.
Number of fixtures in use, . . .	697,640	617,721	644,468	653,189	689,973	698,803	—
Tank fixtures leaking, . . .	959	7,110	10,539	6,035	4,624	6,160	10,888
Faucets leaking, . . .	521	4,655	7,995	2,634	1,963	3,282	5,086
Water-closets leaking, . . .	—	1,080	4,887	1,091	199	223	294
Pipes leaking, . . .	120	413	1,179	362	249	268	426
Wilful waste, . . .	2	164	113	42	22	67	5

The differences between the number of leaks reported in different years are probably due to differences in the thoroughness of the inspection, rather than to the condition of the plumbing.

The results of inspections in several other cities and towns are given as follows:—

CITY OR TOWN.	TAPS, SINKS, BOWLS, BATHS AND WASH TRAYS.		WATER-CLOSETS AND TANKS.	
	Number in use.	Number found leaking.	Number in use.	Number found leaking.
Chelsea,	23,232	1,006	8,813	1,872
Everett,	22,680	548	6,368	1,138
Revere,	8,104	126	2,642	579
Somerville,	—	757	—	1,404
Winthrop,	6,803	69	2,296	101

To a greater degree than in the case of the street mains does the leakage from water fixtures take place from a very large number of small openings which permit of a constant flow. Few people realize that sufficient water will flow, in twenty-four hours, through an orifice of no greater diameter than an ordinary lead pencil, under the average pressure which exists in the pipes throughout the Metropolitan District, to furnish an ample domestic supply for 360 persons; and that in the same time more water will leak through an orifice the size of an ordinary pin than would be used by a fairly economical family of five persons. It is the continual running of thousands of little streams which causes the greater part of waste on the premises of the water takers.

Wilful Waste.

During the winter season large quantities of water are drawn from the pipes by water takers for the purpose of preventing the freezing of water in the house piping; and throughout the year faucets and water-closet fixtures are left or fastened open by water takers for the purpose of flushing water-closets and drain pipes, or in order that the water at the faucet may be constantly kept cool. The legitimate use of water is no larger during the winter season than during the months of November and April, but the actual use in the Metropolitan District is much larger during cold weather than during any other season of the year.

The average use for the months of November and April, compared with the use during intervening months for the past three years, was as follows:—

YEAR.	DAILY AVERAGE (GALLONS).		Difference wasted to prevent freezing of Water in Pipes (Gallons per Day).	Daily Number of Gallons per Capita wasted (Yearly Average).
	November and April.	December, January, February and March.		
1900-01, . . .	90,322,000	104,878,000	14,556,000	5.74
1901-02, . . .	99,317,000	111,417,000	12,100,000	4.61
1902-03, . . .	104,950,000	121,589,000	16,639,000	6.16

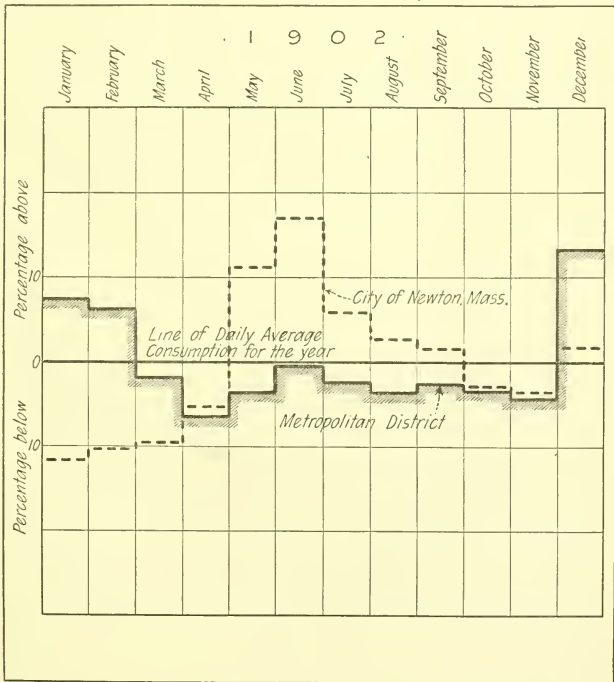
In the cities where meters are in general use, waste of this character does not occur to any great extent, as each property owner is pecuniarily interested so to arrange the plumbing in his buildings

that it does not become necessary to allow water to run in order to prevent it from freezing.

In the district supplied by the Metropolitan Works the use of water during the winter months is much larger than at any other season of the year; while in the city of Newton, where meters are in general use, the minimum use occurs during the winter. This is illustrated by Diagram No. 3.

Diagram No.3

Diagram showing percentage of variation from the daily average consumption of water for the several months of the year 1902 in the Metropolitan District and in the City of Newton, Mass



The effect of cold weather upon the use of water is illustrated very forcibly on Diagram No. 2, on which is shown the rate of

consumption from the Metropolitan Works during each hour of the week ending January 9, 1904. On Tuesday and Wednesday, which were the coldest days of the week, the consumption was about 60,000,000 gallons per day greater than during corresponding days in the month of August; and the lowest rate at which water was drawn from the pipes during the night was 150 gallons per capita, — an amount greater than the maximum rate of use during the corresponding days in August.

The amount wasted during extremely cold weather, as well as the effect of meters in controlling waste, is very forcibly illustrated by diagrams Nos. 4, 5 and 6, which show graphically the use of water in Boston, Chelsea and Malden on January 5, 1904, compared with the use on a day in August, 1903. The cities of Malden and Chelsea have approximately the same population. Malden uses meters on 69 per cent. of its service pipes, Chelsea on 2 per cent. The per capita use in Malden on August 4 was 41 gallons, and in Chelsea 88 gallons. On January 5, 1904, when the average temperature for twenty-four hours was 2 degrees below zero, the per capita use in Malden increased to 57 gallons, and in Chelsea to 211 gallons. In Malden the increase caused by cold weather was about 16 gallons per capita, and in Chelsea 123 gallons. Between the hours of 2 and 4 A.M. on January 5, water was drawn from the pipes in Chelsea at the rate of 192 gallons per day for each inhabitant of the city, and in Boston the rate during the same hours was 178 gallons per capita.

The per capita waste caused by running water to prevent its freezing is largest in those districts where houses are of the cheaper class, but which are furnished with all modern conveniences for the use of water. The cold-weather waste during the week ending January 9, in Chelsea, Charlestown, East Boston and Somerville, was from 60 to 100 gallons per capita; while in Medford, Melrose, Arlington and Quincy it ranged from 15 to 20 gallons.

Diagram showing
Consumption of Water in the City of Boston
during each hour of the day.
Aug. 4, 1903 and Jan. 5, 1904.

Population 599,000. Per cent of services metered 5.27
Average temperature Aug. 4, 61°F; Jan. 5, -2°F.

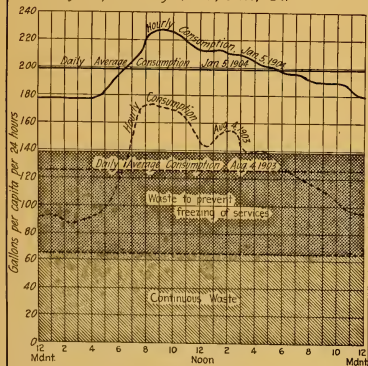


Diagram showing
Consumption of Water in the City of Chelsea
during each hour of the day.
Aug. 4, 1903 and Jan. 5, 1904.

Population 36,000. Per cent of services metered 2.12
Average temperature Aug. 4, 61°F; Jan. 5, -2°F.

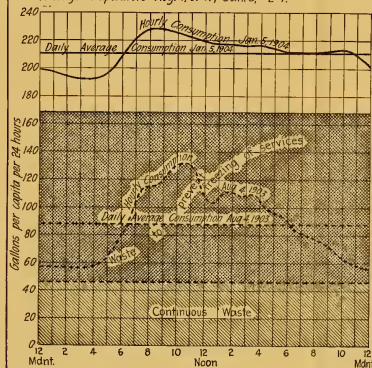
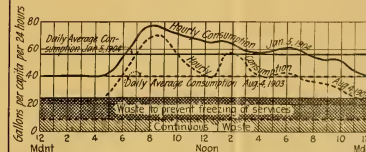


Diagram showing
Consumption of Water in the City of Malden
during each hour of the day
Aug. 4, 1903 and Jan 5, 1904

Population 37,000 Per cent of services metered 69.20
Average temperature Aug 4, 61°F, Jan. 5, -2°F



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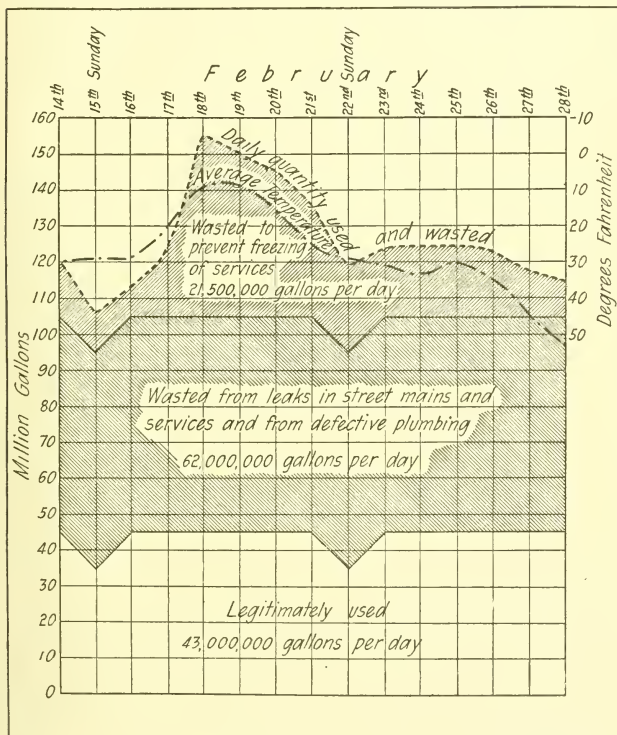
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Diagram No. 7 shows the consumption of water in the city of Boston during a cold period in February, 1903.

Diagram No. 7

Diagram showing daily quantity of water used and wasted in Metropolitan Water District. Feb., 14 to 28, 1903.



The daily average consumption of water previous to the cold weather was about 105,000,000 gallons per day. On February 18, 155,500,000 gallons were used, of which 50,500,000 gallons, equivalent to 57 gallons per capita of the entire population of the District,

were wasted for the purpose of preventing the freezing of service pipes and plumbing.

It is the practice of some water takers to allow water to run continuously from water-closets, for the purpose of cleansing house drains; others permit the water to run from the kitchen faucet, in order that the water may not become warm in the pipes, and some even use a constant stream of water, instead of ice, for the purpose of preserving food. Some water is wasted by each of these methods, but they are sources of waste which are not easily detected by house-to-house inspection, and no attempt has been made to determine the exact amount wasted from these causes.

PREVENTION OF WASTE.

Much waste of water may be prevented by the inspection of house plumbing, and this method, aided by the use of Deacon meters, accomplished good results for several years in the city of Boston. The use of these meters and the work of inspection were begun in 1883, and in 1884 the consumption had been reduced from 91.5 gallons to 68 gallons per capita. The inspection was continued about ten years, but with decreasing diligence; and for ten years previous to 1903 little attention was given to the prevention of waste. In order to obtain facts as to the present condition of affairs, measurements of the consumption during the night have been made by the Boston Water Department during the past year in some of the residential districts of the city by the use of the Deacon meters; and where the measurements indicated a large waste of water, efforts have been made to locate and prevent the same. The measurements were made between the hours of 1 and 4 A.M., when the legitimate use in residential districts is least.

The Deacon meters were first used in the Charlestown district in 1881, and in Table No. 15 the results of measurements made at that time are given, also other measurements made in 1893, about the time active inspection was stopped, as well as those made during the present year.

TABLE NO. 15.

POPULATION OF DISTRICT.			NIGHT RATE OR WASTE (GALLONS PER CAPITA PER DAY).			
1881.	1893.	1903.	Before Inspection, 1881.	After Inspection, 1881.	1893.	1903.
3,675	4,700	4,725	39.0	13.7	24.8	52.8
2,170	2,925	2,975	33.1	13.2	23.8	52.2
1,875	2,325	2,425	44.6	15.1	21.2	63.3
2,030	3,125	3,250	43.2	20.2	40.0	88.0
1,880	1,800	1,800	42.2	22.3	26.7	70.6
1,790	2,150	2,400	53.3	17.8	27.9	53.0
2,540	3,300	3,450	31.9	19.2	26.2	55.7
15,960	20,325	21,025	41.8	17.0	27.3	61.5

There has been very little change in the character of the population or of the plumbing in these sections during the twenty-two years since the first tests were made. By thorough inspection the waste was reduced in 1881 from 41.8 to 17 gallons per capita. Between 1881 and 1893 the inspection was less thoroughly performed, and the waste increased to 27.3 gallons. Since 1895 very little attempt has been made to detect and prevent waste, with the result that the night rate has increased to 61.5 gallons per capita.

The increase in waste in other sections of the city of Boston during the past four years is shown in Table No. 16:—

TABLE NO. 16.

DISTRICT.	Section.	POPULATION.		RATE OF USE BETWEEN 1 AND 4 A.M. (GALLONS PER CAPITA PER DAY).		
		1899.	1903.	1899.	1903.	Increase.
Roxbury, . .	Walnut Avenue, Section 1, . .	2,100	2,150	42.2	81.5	39.3
Roxbury, . .	Walnut Avenue, Section 2, . .	2,200	2,200	31.7	73.1	41.4
Roxbury, . .	Walnut Avenue, Section 3, . .	2,600	2,700	38.4	48.0	9.6
Roxbury, . .	Walnut Avenue, Section 4, . .	1,400	1,500	58.3	116.8	58.5
Roxbury, . .	Warren Street, No. 1, Section 1,	2,150	2,150	88.8	84.8	— 4.0
Roxbury, . .	Warren Street, No. 1, Section 2,	1,100	1,100	30.5	43.6	13.1
Roxbury, . .	Warren Street, No. 1, Section 3,	2,000	2,000	30.0	62.4	32.4
Roxbury, . .	Warren Street, No. 2, Section 1,	2,550	2,650	52.7	56.2	3.5
Roxbury, . .	Warren Street, No. 2, Section 2,	2,800	2,800	54.0	65.1	11.1

TABLE No. 16 — *Concluded.*

DISTRICT.	Section.	POPULATION.		RATE OF USE BETWEEN 1 AND 4 A.M. (GALLONS PER CAPITA PER DAY).		
		1899.	1903.	1899.	1903.	Increase.
Roxbury, . .	Warren Street, No. 2, Section 3,	1,650	1,400	31.3	82.3	51.0
Roxbury, . .	Cedar Street, Section 1, . .	2,100	2,150	40.0	82.6	42.6
Roxbury, . .	Cedar Street, Section 2, . .	2,250	2,400	37.8	79.0	41.2
Roxbury, . .	Cedar Street, Section 3, . .	2,400	2,450	51.5	58.8	7.3
Roxbury, . .	Cedar Street, Section 4, . .	2,500	2,250	32.6	66.1	33.5
Roxbury, . .	Lamartine Street, Section 1, .	2,700	2,700	41.8	106.7	64.9
West Roxbury, .	Spring Park Avenue, Section 1, .	3,950	4,175	27.9	50.0	22.1
West Roxbury, .	Spring Park Avenue, Section 2, .	1,800	1,900	60.0	53.0	— 7.0
West Roxbury, .	Burroughs Street, Section 1, .	1,200	1,450	55.0	72.7	17.7
West Roxbury, .	Burroughs Street, Section 3, .	650	750	59.0	54.4	— 4.6
City proper, . .	Bowdoin Street, Section 1, . .	1,600	1,550	76.5	102.2	25.7
City proper, . .	Bowdoin Street, Section 2, . .	2,400	2,700	58.0	97.8	39.8
City proper, . .	Joy Street, Section 1,	2,500	2,850	28.3	26.0	— 2.3
City proper, . .	Joy Street, Section 2,	2,000	5,000	58.8	69.6	10.8
South Boston, .	Fifth Street, Sections 1 and 2, .	5,600	5,700	41.7	61.0	19.3
		54,200	58,675	—	—	—

It is very evident, from an inspection of the above tables, that at the present time a very large quantity of water is being wasted, and that any system of house-to-house inspection must be continuous in order to be effective. House-to-house inspection is open to the objection that the constant visits of inspectors are annoying to the householders.

While these investigations were in progress, several large leaks were located from the street mains and services; and house-to-house inspection on streets where much waste was noted disclosed in some cases that the house plumbing was in very poor condition. On one street, where the night rate was 5,200 gallons per hour, the inspection disclosed ball cocks wide open, and every faucet in three houses running large streams, the washers being entirely gone. On another street, in fifteen out of sixteen houses examined, the ball cocks were defective, and wasting large streams of water.

In addition to the large leaks which were located in the street mains and service pipes, there are no doubt many smaller leaks still undiscovered; but the inspection proved that the house plumbing is

very defective, and the greater part of the present enormous waste in Boston is probably due to waste on the premises of the water takers.

Effect of using Meters.

The most certain means of detecting waste, and the most effectual means of preventing the extravagant use and waste of water, is that of measuring the water supplied to each municipality, district or individual water taker, and obliging each municipality and individual to pay for water in proportion to the quantity used. Where meters are in use, each water taker finds it to be for his interest to see that the plumbing fixtures which he uses are of the best quality, and that they are kept in repair; that the pipes in his buildings are so located that they will not freeze during cold weather; and that his family or employes are not wasteful in the use of water. The introduction of meters upon all old works has always been followed by a reduction in the quantity of water used; and in cities and towns where they have been introduced when the works were built, the per capita consumption is universally very low. The effect of the use of meters is well illustrated by a comparison between the per capita consumption of water in cities and towns where meters are in general use with that in those where water is paid for at schedule rates. Differences in climate, in character of business and in location, as affecting the available supply of water, often have a marked effect upon the consumption in different cities; but in the following table an attempt has been made to eliminate these differences, as far as possible.

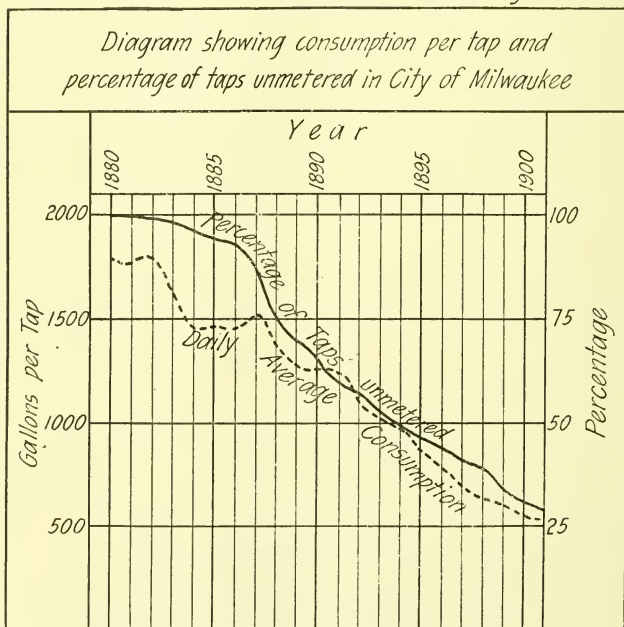
TABLE NO. 17.

CITY OR TOWN.	Number of Consum- ers.	Per Cent. of Services metered.	Consump- tion (Gallons per Day per Con- sumer).	CITY OR TOWN.	Number of Consum- ers.	Per Cent. of Services metered.	Consump- tion (Gallons per Day per Con- sumer).
Milwaukee, Wis.,	308,000	80.0	81.0	Buffalo, N. Y.,	360,000	2.0	324.0
Providence, R. I.,	198,400	84.5	58.0	Indianapolis, Ind.,	169,100	6.0	79.0
Worcester, . . .	119,330	94.5	68.0	New Haven, Ct.,	108,000	2.6	150.0
Fall River, . . .	107,650	96.0	41.0	New Bedford, . .	61,000	18.0	104.0
Lowell,	100,000	65.0	57.0	Cambridge, . . .	94,150	15.0	85.0
Lawrence,	65,000	83.0	53.0	Haverhill,	37,200	10.0	95.0
Brockton,	37,800	90.0	36.0	Lynn,	74,000	25.0	63.0
Newton,	35,400	86.0	54.0	Waltham,	24,550	6.0	99.0
Woonsocket, R. I.,	34,474	96.0	29.0	Salem,	36,250	3.0	79.0
Ware,	7,690	100.0	44.0	Montague,	6,150	2.0	73.0
Wellesley,	5,147	100.0	49.0	Dedham,	7,500	2.0	83.0
Reading,	4,385	100.0	36.0	Braintree,	5,980	1.0	91.0
	1,023,276	-	61.7		983,880	-	178.5

In the first four columns are given the statistics for twelve cities and towns where meters are in general use, and in the following columns corresponding data for an equal number of cities and towns of approximately equal size where few meters are used, but where the conditions as regards location and trade are generally similar. The average per capita consumption where meters are used is but little more than one-third of that in the unmetered cities.

The effect of the use of meters upon the consumption of water is very graphically illustrated by Diagram No. 8, which shows the daily number of gallons used per tap in the city of Milwaukee, and the percentage of unmetered taps for each of the past twenty-two years.

Diagram No. 8



It will be noticed that there has been a gradual reduction in the quantity of water used with the increase in the use of meters. In 1880, with no meters in use, 1,750 gallons were drawn from

each tap; in 1890, with about one-third of the taps metered, the quantity drawn from each was only 1,250 gallons; and in 1902, with 72 per cent. metered, the quantity used per tap was only 550 gallons.

During the past two years the Water Department in the city of Cleveland has been engaged in placing meters upon service pipes. At the end of the year 1902, 11,099 meters were in use on 56,816 services; and the daily average consumption for the year was 69,964,740 gallons. At the close of the year 1903 the number of meters had been increased to 25,193; and the daily average consumption for the year was 62,012,000 gallons. As a result of this work, the daily average consumption for the year 1903 was about 8,000,000 gallons per day less than in 1902, and the greater part of this reduction was no doubt due to the meters set during the previous year.

Effect of Meters upon the Poor.

The fear has been sometimes expressed, by those who have not given the subject careful study, that the use of water meters will have the effect of reducing the use of water by the poorer class of takers below an amount necessary for health. The experience in the cities and towns using meters does not indicate that there need be any fear of such a result. It is the usual custom, where meters are used, to make a uniform minimum charge of from \$10 to \$12 to each water taker, for which sum the taker is entitled to use the quantity for which an equal charge would be made at meter rates. The yearly schedule rate paid by water takers in the different municipalities of the Metropolitan District for the use of one faucet and a water-closet is generally from \$9 to \$11, and the rate for a single faucet is \$5. For \$10 per annum per taker, every person in a family of average size, if supplied by meter at the rate of 14 cents per 100 cubic feet, which is the rate generally in force throughout the District, will have the privilege of using 30 gallons, or twelve pailfuls of water per day, which experience shows to be ample for domestic use. In many municipalities where water used for domestic purposes is metered, exception is made in cases where premises are supplied through a single faucet, and the schedule rate remains in force. There appears to be no reason, however, why a minimum rate of \$5 per year should not be made for premises of this kind supplied by meter. Experience shows that the majority of the water

takers using water for domestic purposes use less than the quantity to which they are entitled by the minimum charge.

In the city of Malden the minimum yearly charge is \$12, for which sum each water taker is entitled to use 47,470 gallons, equivalent to 130 gallons per day, or 26 gallons per day for each member of a family of average size. In the year 1901 the total number of meters on domestic services was 3,490, and the daily average number of gallons used by each service was 112.8. The number using less than the minimum quantity was as follows:—

CUBIC FEET PER YEAR.	Number of Services.	Gallons per Day per Service.	CUBIC FEET PER YEAR.	Number of Services.	Gallons per Day per Service.
Less than 500,	28	* 6.4	Between 3,000 and 4,000, .	566	72.0
Between 500 and 1,000, .	52	* 16.1	Between 4,000 and 5,000, .	560	92.0
Between 1,000 and 2,000, .	259	* 33.9	Between 5,000 and 6,300, .	621	114.0
Between 2,000 and 3,000, .	441	52.5		2,527	77.4

* Many of these were metered for but a portion of the year.

In the city of Providence the minimum charge is \$10 per annum, for which each taker or service is entitled to use 91.32 gallons per day. In 1888 an analysis was made to show the number of takers using less than the quantity permitted by the minimum rate, with the following result:—

CUBIC FEET PER YEAR.	Number of Services.	Gallons per Day per Service.	CUBIC FEET PER YEAR.	Number of Services.	Gallons per Day per Service.
Less than 1,500,	187	30.74	Between 3,000 and 3,500, .	446	71.73
Between 1,500 and 2,000, .	237	40.99	Between 3,500 and 4,000, .	462	81.98
Between 2,000 and 2,500, .	361	51.23	Between 4,000 and 4,457, .	435	91.32
Between 2,500 and 3,000, .	445	61.48		2,553	66.70

The total number of meter accounts at this time, including those for trade, manufacturing and mechanical use, was 7,074, of which 5,110, or 72 per cent., paid less than \$20 per year.

Use of Meters on Street Mains.

As has been already stated on previous pages, there is a large leakage from the pipes in the streets, and this cannot be detected ex-

Diagram No. 9

48 INCH VENTURI METER. 18 INCH THROAT
METROPOLITAN WATER AND SEWERAGE BOARD.

48 INCH VENTURI METER. 18 INCH THROAT.
METROPOLITAN WATER AND SEWERAGE BOARD.

40 000 000 *S.H.S. Sta 5 (Boston) Boylston St and Fisher Ave. Brookline*

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BUILDERS IRON FOUNDRY

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PROVIDENCE, R. I.

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20 INCH VENTURI METER. 6 1/2 INCH THROAT.
METROPOLITAN WATER AND SEWERAGE BOARD.

20 INCH VENTURI METER. 6 1/2 INCH THROAT
METROPOLITAN WATER AND SEWERAGE BOARD.

5 000 000 *N.L.S. Sta 24 (Medford) High St and Governor's Ave*

5 000 000

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PROVIDENCE, R. I.

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*Sept. 10 Break in
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*July 22, Break on H.S. (Local)
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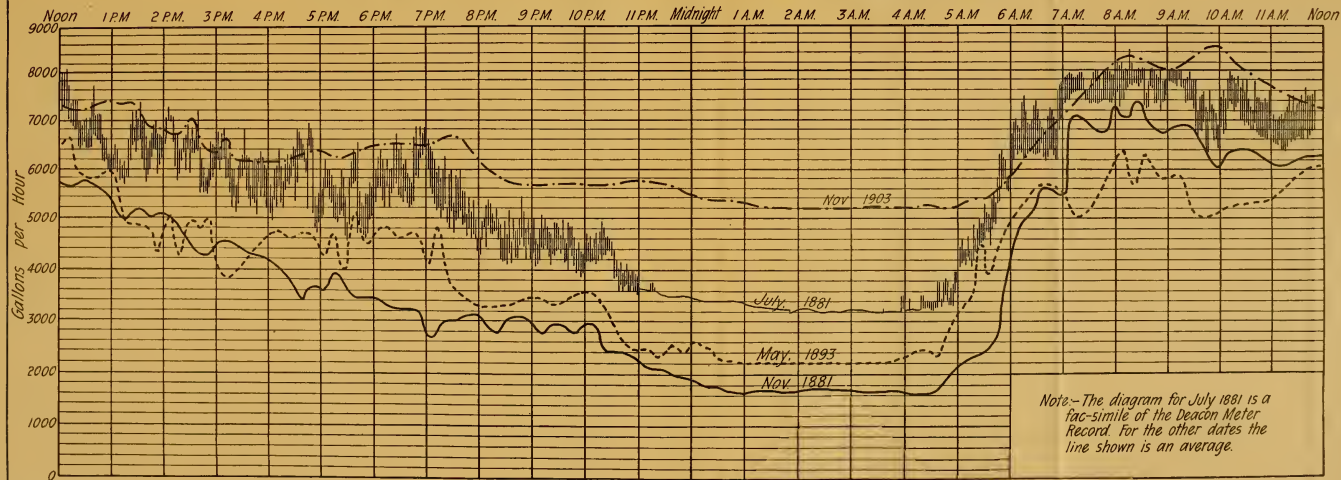
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Diagram showing Hourly Rate of Consumption in a Portion (Section, Winthrop 2) of Charlestown District, City of Boston.

Summary of Tests

Date	Population	Rate, Gallons per Hour		Gallons per capita per day		Remarks
		Average for 24 hrs.	Night Rate (waste)	Average for 24 hrs.	Night Rate (waste)	
July, 1881	1880	5350	3300	68.4	42.2	Before inspection
Nov. 1881	1880	3750	1740	47.8	22.3	After two or three inspections
May, 1893	1800	4100	2200	54.7	29.3	Inspection continued until July 1895
Nov. 1903	1825	6400	5200	84.0	68.4	No inspection for 8 years



Note:—The diagram for July 1881 is a fac-simile of the Deacon Meter Record. For the other dates the line shown is an average.

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cept in the aggregate, and cannot be prevented by measuring the water supplied to each taker. Underground leaks in the streets can be best located by placing meters on the street mains, in such a manner that districts containing from 2,000 to 5,000 persons can be isolated from the remainder of the pipe system. The type of meter used for buildings is not well adapted to this service, but either the Venturi meter previously described, or the Deacon waste-water meter, which has been used in Boston for detecting waste, can be used to good advantage. Both of these meters record the rate at which water is drawn through them, and by closing valves on the pipes, the leaks, both in mains and service pipes, can be located within narrow limits. The Deacon meter gives a continuous record of the rate of flow; the Venturi meter records the rate of flow at intervals of ten minutes.

Samples of the records made by both of these types of meters are shown on the following pages.

The Venturi meter records, shown on Diagram No. 9, are full size facsimiles of original records, showing the increased draft caused by leaks in street mains. On Diagram No. 10 is shown, on a slightly reduced scale, the facsimile of a record made by a Deacon meter in July, 1881, before any attempt had been made to prevent waste, together with records made at later dates. It will be noticed that the record of November, 1881, shows a line approximately parallel with the record made in the preceding July, indicating that the reduction due to stopping waste was continuous throughout the twenty-four hours. It is also noticeable that the draft during the day was but very little larger in November, 1903, than it was in July, 1881, twenty-two years before, while the night rate or waste in 1903 was the largest recorded.

By the most thorough inspection it is not practicable to prevent all underground waste of water, and the best results can only be obtained by a force of well-trained, conscientious employés. This condition of affairs is more or less difficult of attainment, but it is perfectly feasible to reduce the underground waste to from 10 to 15 gallons per capita, and the total waste, including that in buildings, to from 15 to 20 gallons.

METHOD OF ASSESSMENT.

By the present method of apportioning the amount required to pay the interest, sinking fund requirements, and expenses of mainte-

nance and operation for the Metropolitan Water District, the city of Boston pays in the proportion that its valuation bears to the total valuation of the whole water district; and the remaining cities and towns pay the remainder of the required amount, one-third in proportion to their respective valuations and two-thirds in proportion to their respective populations, including, however, only one-sixth of the total valuation and one-sixth of the total population of any city and town which has not reached the safe capacity of its sources of supply, and has not made application for a supply of water. By this method of assessment the proportion paid by the several municipalities is not affected by the quantity used, and, although each municipality should be interested to keep the cost of constructing and maintaining works as small as possible, the inducement to prevent waste of water is general rather than special, especially in the smaller cities and towns. Under the present system, those cities and towns where the quantity of water used is kept within reasonable limits, either by the use of meters or by inspection, pay a higher rate for the water used than those where meters are not in use, and little or no attempt is made to prevent waste. This is shown by the following table (No. 18), giving the cost to each municipality of the water used during the year 1903. The quantity used has been determined from actual measurement during the last six months of the year, and estimated for the remaining time.

TABLE NO. 18.

CITY OR TOWN.	Amount of Assessment for 1903.	Estimated Quantity used (Million Gallons).	Cost per Million Gallons.
Boston,	\$1,510,857 46	29,382.50	\$51 42
Somerville,	77,288 43	2,120.65	36 45
Malden,	41,635 31	646.05	64 45
Chelsea,	39,877 54	1,277.50	31 21
Everett,	29,794 15	857.75	34 73
Quincy,	30,237 42	912.50	33 14
Medford,	24,654 86	602.25	40 05
Melrose,	17,815 34	511.00	34 86
Revere,	13,771 64	299.30	46 01
Watertown,	13,440 83	182.50	73 65
Arlington,	11,549 55	244.55	47 23
Milton,	14,813 20	120.45	122 79
Winthrop,	8,653 44	244.55	35 38
Stoneham,	7,523 04	164.25	45 80
Belmont,	5,701 23	80.30	71 00
Lexington,	5,733 77	87.60	64 47
Nahant,	3,211 08	51.10	62 84
	\$1,856,558 29	37,784.80	\$49 14

In order to show the effect of using the quantity of water consumed as a factor in determining the amount to be paid by the several municipalities, the following statements have been prepared, showing the results under different conditions. The assessments of Newton and Hyde Park have been based upon one-sixth of the quantity of water consumed in 1903.

TABLE NO. 19.

If each city and town had been assessed for the year 1903 in proportion to the quantity of water used, the amounts paid would have been as follows:—

CITY OR TOWN.	Amount of Assessment, on Basis above given.	DIFFERENCE, COMPARED WITH ACTUAL ASSESSMENT.	
		Less.	More.
Boston,	\$1,445,761 76	\$65,095 70	-
Somerville,	104,340 45	-	\$27,052 02
Newton,	6,815 74	2,937 13	-
Malden,	31,784 22	9,851 09	-
Chelsea,	62,858 40	-	22,980 86
Everett,	42,210 80	-	12,416 65
Quincy,	44,901 52	-	14,664 10
Medford,	29,635 38	-	4,980 52
Hyde Park,	3,045 76	-	295 84
Melrose,	25,150 83	-	7,335 49
Revere,	14,724 26	-	952 62
Watertown,	8,987 78	4,453 05	-
Arlington,	12,033 53	-	483 98
Milton,	5,923 34	8,889 86	-
Winthrop,	12,033 53	-	3,380 09
Stoneham,	8,072 18	-	549 14
Belmont,	3,942 66	1,758 57	-
Lexington,	4,316 38	1,417 39	-
Nahant,	2,522 56	688 52	-
	\$1,868,561 08	\$95,091 31	\$95,091 31

TABLE NO. 20.

If the city of Boston had been assessed in proportion to its valuation, and the remainder of the amount divided among the remaining municipalities in proportion to the quantity of water used by each, the results would have been as follows:—

CITY OR TOWN.	Amount of Assessment, on Basis above given.	DIFFERENCE, COMPARED WITH ACTUAL ASSESSMENT.	
		Less.	More.
Boston,	\$1,510,857 46	-	-
Somerville,	88,281 25	-	\$10,992 82
Newton,	5,340 52	\$3,912 35	-
Malden,	26,895 73	14,739 58	-
Chelsea,	53,179 80	-	13,302 26
Everett,	35,705 97	-	5,911 82
Quincy,	37,988 12	-	7,750 70
Medford,	25,071 45	-	416 59
Hyde Park,	2,582 62	167 30	-
Melrose,	21,272 63	-	3,457 29
Revere,	12,458 82	1,312 82	-
Watertown,	7,597 63	5,843 20	-
Arlington,	10,180 24	1,369 31	-
Milton,	5,015 00	9,798 20	-
Winthrop,	10,180 25	-	1,526 81
Stoneham,	6,835 72	687 32	-
Belmont,	3,340 95	2,360 28	-
Lexington,	3,648 58	2,085 19	-
Nahant,	2,128 34	1,082 74	-
	\$1,868,561 08	\$43,358 29	\$43,358 29

TABLE NO. 21.

If the city of Boston had been assessed in proportion to its valuation, and the remainder of the amount divided among the remaining municipalities, one-third in proportion to valuation and two-thirds in proportion to the quantity of water used, the results would have been as follows: —

CITY OR TOWN.	Amount of Assessment, on Basis above given.	DIFFERENCE, COMPARED WITH ACTUAL ASSESSMENT.	
		Less.	More.
Boston,	\$1,510,857 46	-	-
Somerville,	82,311 18	-	\$5,022 75
Newton,	7,923 14	\$1,329 73	-
Malden,	30,168 72	11,466 59	-
Chelsea,	45,575 02	-	5,697 48
Everett,	32,347 14	-	2,552 99
Quincy,	34,693 67	-	4,456 25
Medford,	25,436 30	-	781 44
Hyde Park,	2,543 27	206 65	-
Melrose,	20,678 85	-	2,863 51
Revere,	12,998 95	772 69	-
Watertown,	10,030 01	3,410 82	-
Arlington,	10,824 11	725 44	-
Milton,	12,412 32	2,400 88	-
Winthrop,	10,151 63	-	1,498 19
Stoneham,	6,667 60	855 44	-
Belmont,	4,496 33	1,204 90	-
Lexington,	4,821 84	911 93	-
Nahant,	3,623 54	-	412 46
	\$1,868,561 08	\$23,285 07	\$23,285 07

TABLE NO. 22.

If the assessment for 1903 had been divided among all the municipalities, including Boston, one-third in proportion to valuation and two-thirds in proportion to quantity used, the results would have been as follows: —

CITY OR TOWN.	Amount of Assessment, on Basis above given.	DIFFERENCE, COMPARED WITH ACTUAL ASSESSMENT.	
		Less.	More.
Boston,	\$1,467,474 44	\$43,383 02	-
Somerville,	93,016 97	-	\$15,728 54
Newton,	8,576 70	676 17	-
Malden,	33,428 56	8,206 75	-
Chelsea,	52,020 74	-	12,143 20
Everett,	36,679 85	-	6,885 70
Quincy,	39,295 84	-	9,058 42
Medford,	28,476 87	-	3,822 01
Hyde Park,	2,858 90	-	108 98
Melrose,	23,263 58	-	5,448 24
Revere,	14,518 72	-	747 08
Watertown,	10,949 77	2,491 06	-
Arlington,	12,052 22	-	502 67
Milton,	13,023 87	1,789 33	-
Winthrop,	11,379 54	-	2,726 10
Stoneham,	7,492 93	30 11	-
Belmont,	4,895 63	805 60	-
Lexington,	5,269 34	464 43	-
Nahant,	3,886 61	-	675 53
	\$1,868,561 08	\$57,846 47	\$57,846 47

TABLE NO. 23.

If the assessment for 1903 had been divided among all the cities and towns, one-half in proportion to valuation and one-half in proportion to quantity used, the results would have been as follows:—

CITY OR TOWN.	Amount of Assessment, on Basis above given.	DIFFERENCE, COMPARED WITH ACTUAL ASSESSMENT.	
		Less.	More.
Boston,	\$1,478,312 10	\$32,545 36	-
Somerville,	87,355 23	-	\$10,066 80
Newton,	9,716 52	-	463 65
Malden,	34,250 73	7,384 58	-
Chelsea,	46,601 91	-	6,724 37
Everett,	33,914 38	-	4,120 23
Quincy,	36,511 68	-	6,274 26
Medford,	27,897 62	-	3,242 76
Hyde Park,	2,746 78	3 14	-
Melrose,	22,329 31	-	4,513 97
Revere,	14,406 61	-	634 97
Watertown,	11,940 10	1,500 73	-
Arlington,	12,070 91	-	521 36
Milton,	16,555 45	-	1,742 25
Winthrop,	11,061 88	-	2,408 44
Stoneham,	7,212 65	310 39	-
Belmont,	5,362 77	338 46	-
Lexington,	5,736 48	-	2 71
Nahant,	4,577 97	-	1,366 89
	\$1,868,561 08	\$42,082 66	\$42,082 66

TABLE No. 24.

If the assessment for 1903 had been divided as follows: Boston, two-thirds in proportion to valuation, one-third in proportion to water used; and other municipalities, one-third in proportion to valuation, two-thirds in proportion to quantity used, the results would have been as follows:—

CITY OR TOWN.	Amount of Assessment, on Basis above given.	DIFFERENCE, COMPARED WITH ACTUAL ASSESSMENT.	
		Less.	More.
Boston,	\$1,489,162 83	\$21,694 63	-
Somerville,	87,303 33	-	\$10,014 90
Newton,	8,403 67	849 20	-
Chelsea,	48,339 13	-	8,461 59
Malden,	31,998 45	9,636 86	-
Everett,	34,308 98	-	4,514 83
Quincy,	36,797 84	-	6,560 42
Medford,	26,979 01	-	2,324 15
Hyde Park,	2,697 52	52 40	-
Melrose,	21,933 01	-	4,117 67
Revere,	13,787 33	-	15 69
Watertown,	10,638 33	2,802 50	-
Arlington,	11,480 59	68 96	-
Milton,	13,165 12	1,648 08	-
Wiothrop,	10,767 32	-	2,113 88
Stoneham,	7,071 98	451 06	-
Belmont,	4,769 04	932 19	-
Lexington,	5,114 29	619 48	-
Nahant,	3,843 31	-	632 23
	\$1,868,561 08	\$38,755 36	\$38,755 36

By the provisions of the Act constituting the Metropolitan Water District, the city of Boston was paid for all of its supply works, while those of the other cities and towns were not taken, with the exception of Spot Pond and pumping stations on its shores, which were the property of the cities of Malden, Medford and Melrose. The works of the cities of Quincy and Newton and of the towns of Arlington, Revere, Watertown, Lexington and Hyde Park, also portions of the works supplying water to Malden, Melrose and Medford, were not taken, and are now of little value, excepting those of Newton and Hyde Park, which still furnish those municipalities.

These facts were considered in fixing the proportion of the cost to be paid by Boston and the other municipalities, and the part to be paid by the city of Boston was based upon its valuation in proportion to the valuation of the whole District. The proportion of the valuation of the city of Boston to that of the whole District is larger than the corresponding percentage of its population or of the quantity of water used; for this reason, any change in the present method of assessment of the whole district, by substituting the quantity of water used for population, will decrease the assessment of the city of Boston.

For the year 1903 the percentages of valuation, population and water used in the several municipalities were as follows:—

TABLE NO. 25.—*Showing the Proportion of Valuation, Population and Quantity of Water used for the Year 1903; also, the Proportion of Metropolitan Water Assessment paid by the Several Cities and Towns.*

CITY OR TOWN.	Percentage of Valuation.	Percentage of Estimated Population.	Percentage of Water used.	Percentage paid on Present Basis of Estimate.
Boston,	80.857	66.284	77.373	80.857
Somerville,	3.767	7.505	5.584	4.136
Newton,* . . . . .	.701	.700	.338	.495
Malden,	1.965	4.098	1.701	2.228
Chelsea,	1.625	3.980	3.364	2.134
Everett,	1.371	3.313	2.259	1.595
Quincy,	1.504	2.977	2.403	1.618
Medford,	1.400	2.303	1.586	1.320
Hyde Park,* . . . . .	.132	.263	.163	.147
Melrose,	1.043	1.542	1.346	.953
Revere, . . . . .	.754	1.436	.788	.737
Watertown, . . . . .	.797	1.201	.481	.719
Arlington, . . . . .	.648	1.079	.644	.618
Milton,	1.456	.820	.317	.793
Winthrop, . . . . .	.540	.815	.644	.463
Stoneham, . . . . .	.339	.706	.432	.403
Belmont, . . . . .	.364	.533	.211	.395
Lexington, . . . . .	.383	.398	.231	.307
Nahant, . . . . .	.354	.247	.135	.172
	100.000	100.000	100.000	100.000

* Percentages for Newton and Hyde Park are based upon one-sixth of the valuation, population and water used.

In view of the conditions under which the present method of apportioning the assessment was established, it does not appear to be equitable to so radically modify the same as to eliminate entirely the factor of valuation. On the other hand, it is very desirable that the assessment shall be divided in such a manner that each city and town shall feel a pecuniary interest in preventing the waste of water. The city of Malden, and the towns of Belmont, Milton and Watertown, have, by the general use of meters, prevented to a great extent the waste of water within their limits; while in most of the other cities and towns in the District very little attention is given to any means of preventing unnecessary use and waste. From a business point of view, it seems proper that those municipalities which adopt measures to prevent waste of water, and thus reduce the expense of constructing and maintaining the Metropolitan Water Works, should receive a direct benefit, and that they should not be obliged to pay for the negligence of others. This can to some extent be accomplished by using both valuation and quantity of water as factors in determining the proportion to be paid; and if each of these factors is given equal value, the results will, as a whole, be an improvement upon the present method.

REASONS FOR CHECKING WASTE.

The quantity of water that will be required in the future to supply cities and towns now furnished with water from the Metropolitan Works is estimated as follows, the figures in the second and third columns being the quantities that will be needed if waste is not checked, and those in the fourth and fifth columns those required if water is sold to all consumers by measurement, and waste of water prevented as far as practicable, assuming, in both cases, an increasing consumption per capita.

YEAR.	WASTE NOT CHECKED.		WASTE PREVENTED.	
	Gallons per Capita.	Million Gallons per Day.	Gallons per Capita.	Million Gallons per Day.
1910,	134	152	80	90
1915,	144	181	85	107
1920,	154	219	90	128
1925,	164	262	95	150
1930,	174	310	100	175

The estimated safe capacity of the Cochituate, Sudbury and Nashua River works is 173,000,000 gallons per day ; and, if present conditions are allowed to continue, additional sources of supply will be required by 1913, the construction of which will require several years, so that within five years from the time when the Nashua River works now being built will be finished the construction of new works will be called for.

The sources which were suggested in 1895 by the State Board of Health, in its report on additional water supply, as available for supplementing the supply from the Nashua River, are as follows : —

	Estimated Available Yield (Million Gal- lons per Day).	Total Available from all Sources (Million Gal- lons per Day).
Assabet River,	28	201
Upper Ware River,	71	272
Lower Ware and Swift rivers,	200	472

The addition of the Assabet River will be followed almost immediately by works from the Upper Ware River, and within eighteen years the construction of works from the Swift River will become necessary. In order to distribute the increasing quantity of water to the several municipalities, no less than ten lines of large pipes will be required, leading from the terminus of the Weston Aqueduct, and additional main pipes will also be required in different portions of the District. Additional pumping machinery will also be needed.

It is estimated that the cost of the new works required within the next twenty-five years to supply the probable demand for water, if waste is unchecked, will be at least \$32,000,000, assuming that the District remains constituted as at present. If other cities and towns are added, as is probable, the time when the additional works will be needed will be shortened.

Not only is the cost of constructing and maintaining the works necessary for supplying water to the Metropolitan District increased by the waste of water, but the cost of the works required to dispose of the water after it has been delivered to the water takers is also increased. The greater part of the water that is wasted runs into the sewers, and is pumped one or more times before being discharged into the ocean. The North Metropolitan Sewerage Works,

when built, about ten years ago, were expected to have a capacity sufficient to meet the demands of the District until 1930 ; but it has already been found necessary to duplicate some portions of the system, and within a comparatively few years the entire system must be duplicated, if the quantity of sewage to be provided for continues to increase at the present rate. The city of Boston has been obliged to construct new reservoirs and pumping machinery, and new and extensive works are now being constructed to relieve the Boston system of a portion of the sewage now cared for. The total cost of the Metropolitan and Boston main drainage systems has been about \$19,000,000 ; and larger sewers and additional pumping machinery will be required, and increased cost of maintenance will result, if waste of water is allowed to continue to increase. All the available sources of water supply east of the Connecticut River will be required during the next twenty-five years, and an immense sum of money must be expended for the construction of works to bring to the District water which will serve no useful purpose, but will, on the other hand, cause inconvenience and expense to the Metropolitan District, through making necessary additional water mains and sewerage works.

In conclusion, I desire to express my appreciation of the assistance furnished, during the progress of the investigations and the preparation of this report, by the officials in charge of the water departments in the several municipalities of the District.

Table No. 26, appended to this report, gives the daily average number of gallons of water used during each week from June 28, 1903, to January 2, 1904, in the several cities and towns supplied from the Metropolitan Water Works ; and Table No. 27 contains statistics relative to the consumption of water, number of services and meters in use, revenue from sale of water, etc., in twenty-one of the large cities of the United States.

Respectfully submitted,

DEXTER BRACKETT,

Engineer, Distribution Department.

TABLE NO. 27. — *Water Works Statistics of the Large Cities of the United States for the Year 1902.*

CITIES.	Population.	Total Daily Consumption (Gallons).	Daily Average Metered Con- sumption (Gallons).	Number of Services.	Number of Meters.	Miles of Pipe.	Consumption per Capita (Gallons).	Metered Consumption per Capita (Gallons).	Per Cent. of Consumption metered.	Per Cent. of Services metered.	Total received for Water.	Receipts for Metered Water.	Per Cent. received for Metered Water.	Total received per Million Gallons.	Received for Metered Water per Million Gallons.
New York (Manhattan),	2,001,000	282,000,000	64,240,000	150,000	37,493	897.00	105.0	30.7	22.80	25.00	\$6,562,894 00	\$3,132,816 00	56.00	\$54 34	\$135 00
Chicago, Ill.,	2,260,000	368,101,700	41,008,000	324,200	7,075	1,918.80	169.0	18.3	11.50	2.18	3,164,910 53	1,820,684 09	42.00	24 21	86 00
Philadelphia, Pa.,	1,849,500	313,992,900	16,430,400	255,400	1,510	1,381.60	233.0	12.2	5.23	.50	5,450,095 87	226,684 10	6.56	30 20	28 00
Metropolitan Water District,	874,200	107,268,000	21,213,500	141,600	13,073	1,457.00	122.7	24.4	19.80	9.24	3,243,634 53	1,286,227 15	39.70	82 85	166 12
St. Louis, Mo.,	650,000	87,000,000	15,140,000	72,005	4,635	700.00	184.0	23.3	17.41	8.41	1,748,541 21	760,645 50	43.50	55 00	137 00
Boston,	-	-	17,521,400	89,337	5,164	727.00	-	29.9	-	8.03	2,308,191 98	1,005,312 25	43.60	-	157 19
Baltimore, Md.,	625,000	59,647,900	13,226,000	100,151	2,182	634.00	114.0	25.2	22.17	2.17	654,630 72	264,283 06	47.80	25 50	65 00
Cleveland, O.,	424,000	89,964,500	19,050,900	56,816	11,099	577.00	165.0	45.0	27.23	21.11	864,140 11	433,778 81	50.20	33 90	62 00
Buffalo, N. Y.,	360,000	116,810,400	16,561,800	67,531	1,375	500.45	324.0	46.0	14.12	2.04	682,020 21	185,550 75	19.80	16 00	23 00
Cincinnati, O.,	345,400	43,033,000	10,513,670	37,302	3,607	440.00	124.8	50.4	24.40	9.67	800,070 50	334,505 82	41.70	51 00	88 00
Pittsburg, Pa.,	260,000	63,800,000	4,270,000	36,112	294	392.50	246.0	16.4	6.71	1.00	774,042 64	177,323 00	22.90	33 20	114 00
Detroit, Mich.,	327,000	61,890,900	14,970,800	63,342	5,847	617.00	157.0	42.7	29.17	9.24	548,290 81	126,170 40	54.40	21 20	25 00
Milwaukee, Wis.,	308,000	25,010,800	-	45,480	32,721	370.00	81.0	-	-	71.84	531,853 28	305,112 69	57.50	58 20	-
Newark, N. J.,	290,000	20,000,000	-	38,278	13,275	263.00	100.0	-	-	36.60	695,161 05	361,932 88	54.00	73 20	-
Louisville, Ky.,	241,000	16,582,600	-	23,877	1,944	254.00	68.8	-	-	8.14	410,666 17	169,298 87	41.16	67 80	-
Indianapolis, Ind.,	200,000	15,653,100	-	11,459	650	225.90	78.0	-	-	5.67	282,231 31	-	-	49 40	-
Providence, R. I.,	198,400	11,563,400	-	22,758	19,216	-	68.0	-	-	84.50	605,307 35	512,051 65	84.60	143 50	-
Toledo, O.,	140,000	9,823,900	-	12,864	8,292	176.20	70.0	-	-	48.85	156,636 19	112,750 37	74.80	42 10	-
Worcester,	124,500	8,094,800	4,331,000	13,832	13,076	180.90	65.0	34.8	53.55	94.60	270,088 81	267,500 87	97.20	91 50	106 00
Petersboro, N. J.,	109,600	9,900,000	1,390,400	11,669	3,000	113.90	91.0	12.8	14.00	25.70	-	-	-	-	-
Fall River,	108,700	4,365,100	-	7,282	8,973	62.70	40.1	-	-	-	175,856 95	171,077 36	-	110 20	-

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TABLE No. 26. — *Daily Average Number of Gallons of Water used in the Several Cities and Towns supplied from the Metropolitan Water Works during Each Week from June 28, 1903, to January 2, 1904, as measured by Venturi Meters.*

WEEK ENDING —		Boston.	Somerville.	Malden.	Chelsea.	Everett.	Quincy.	Medford.	Melrose.	Revere.
July 4,	.	76,482,700	6,086,800	1,853,100	3,326,900	2,206,700	2,612,200	1,602,400	1,396,400	782,100
July 11,	.	79,510,700	6,478,300	1,912,400	3,507,500	2,212,200	2,964,800	1,810,900	1,525,700	915,000
July 18,	.	77,770,900	6,208,400	2,002,000	3,394,700	2,290,000	2,992,900	1,946,100	1,570,100	929,100
July 25,	.	73,421,300	5,371,400	1,731,100	3,155,700	1,986,900	2,971,100	1,574,000	1,378,900	802,000
August 1,	.	75,708,300	5,588,000	1,910,900	3,252,700	2,168,700	2,454,400	1,467,100	1,446,100	878,700
August 8,	.	73,705,200	5,143,100	1,613,700	3,226,700	2,113,500	2,256,100	1,535,000	1,400,300	819,400
August 15,	.	76,638,200	5,548,000	1,735,000	3,173,000	2,115,100	2,457,100	1,485,000	1,413,000	853,600
August 22,	.	76,178,300	5,458,500	1,829,500	3,192,000	2,235,300	2,471,400	1,624,500	1,433,100	889,400
August 29,	.	75,117,800	5,284,400	1,737,100	3,093,700	2,283,700	2,464,900	1,667,100	1,386,100	891,600
September 5,	.	74,989,000	5,224,700	1,884,000	3,078,100	2,215,600	2,328,700	1,554,700	1,319,000	792,600
September 12,	.	76,318,000	5,551,200	2,070,100	3,078,100	2,243,700	2,361,400	1,719,300	1,408,400	834,900
September 19,	.	79,178,500	6,075,000	2,070,100	3,271,300	2,335,700	2,489,100	1,899,600	1,535,100	880,100
September 26,	.	77,764,900	5,622,000	1,954,000	3,240,800	2,204,700	2,410,900	1,777,500	1,448,600	783,000
October 3,	.	76,847,200	5,691,200	1,841,600	3,277,200	2,204,700	2,324,700	1,764,700	1,485,600	733,900
October 10,	.	76,597,700	5,668,900	1,751,400	3,233,400	2,130,700	2,260,600	1,680,300	1,440,400	708,700
October 17,	.	77,009,800	5,303,900	1,688,900	3,190,400	2,177,900	2,267,300	1,618,400	1,395,000	693,000
October 24,	.	76,949,600	5,312,400	1,800,800	3,196,100	2,244,800	2,267,300	1,618,400	1,407,400	698,700
October 31,	.	76,689,600	5,298,400	1,697,400	3,121,700	2,285,100	2,314,400	1,622,700	1,385,100	707,400
November 7,	.	77,502,200	5,320,800	1,692,500	3,095,000	2,333,400	2,300,300	1,620,100	1,400,000	704,000
November 14,	.	77,384,500	5,284,000	1,638,600	3,157,100	2,302,300	2,292,100	1,575,500	1,344,500	686,400
November 21,	.	75,903,100	5,283,700	1,620,600	3,141,400	2,330,000	2,233,100	1,585,100	1,315,900	673,400
November 28,	.	76,904,000	5,108,900	1,559,500	3,337,400	2,379,700	2,239,600	1,597,000	1,312,600	685,500
December 5,	.	81,096,600	5,515,603	1,567,700	3,714,500	2,553,600	2,373,700	1,588,400	1,314,900	707,700
December 12,	.	79,365,400	5,350,700	1,589,900	3,495,800	2,641,000	2,346,900	1,549,900	1,304,700	711,800
December 19,	.	86,711,200	5,912,300	1,583,500	4,054,900	2,641,600	2,455,400	1,651,900	1,325,300	831,200
December 26,	.	86,086,000	6,006,200	1,768,000	4,546,900	2,713,100	2,692,700	1,745,800	1,279,500	853,500
January 2,	.	94,639,400	6,487,300	1,750,800	5,080,300	2,852,000	2,483,400	1,773,200	1,301,000	961,000
Average gallons p. r. day,		78,228,200	5,600,300	1,764,400	3,308,900	2,306,700	2,415,200	1,653,500	1,395,100	795,700

TABLE No. 26 — *Concluded.*

WEEK ENDING —	Watertown.	Arlington.	Milton.	Winthrop.	Stoneham.	Belmont.	Lexington.	Nahant.	Swampscott.	Total.
July 4,	528,700	722,700	302,900	683,000	377,100	165,200	292,000	335,000	604,900	100,350,800
July 11,	611,200	854,200	365,300	817,700	509,700	214,100	352,300	379,900	726,700	105,605,600
July 18,	636,700	941,200	375,500	814,000	483,600	262,900	253,000	389,600	736,100	104,066,800
July 25,	606,700	737,000	270,900	589,600	497,100	170,400	205,400	215,600	690,000	95,378,100
August 1,	587,300	695,400	366,700	767,700	496,600	213,300	243,000	256,600	710,900	99,206,400
August 8,	522,700	670,000	334,700	768,900	512,000	215,900	261,300	232,200	696,600	96,117,300
August 15,	581,100	630,000	354,700	750,000	508,000	244,300	269,000	213,200	708,900	98,658,600
August 22,	559,200	630,200	344,800	764,000	521,000	235,100	278,400	289,000	726,400	100,260,100
August 29,	544,200	651,900	317,000	775,600	499,000	228,800	312,600	234,300	745,000	98,455,100
September 5,	496,400	538,900	290,100	663,100	447,900	208,700	274,900	159,600	658,400	96,994,100
September 12,	554,300	624,400	377,000	690,400	441,900	188,100	321,900	180,900	659,400	99,395,600
September 19,	594,100	634,700	400,700	762,300	491,900	308,000	327,600	238,500	653,400	104,174,700
September 26,	579,700	634,700	378,000	683,100	461,700	274,600	309,100	204,700	485,900	101,117,900
October 3,	558,400	617,200	356,100	639,300	438,000	281,100	296,100	267,700	508,000	100,034,700
October 10,	529,000	553,200	312,500	597,300	428,600	254,700	259,600	103,100	425,900	98,984,700
October 17,	577,700	564,400	301,400	594,000	416,300	236,400	209,700	91,500	456,900	98,695,900
October 24,	504,100	556,700	330,400	603,900	446,700	243,900	223,900	51,900	470,100	98,897,200
October 31,	478,400	525,800	330,000	600,000	476,600	230,600	215,900	62,900	436,400	98,495,600
November 7,	522,400	543,300	349,400	580,300	449,400	229,400	188,600	40,000	399,600	99,293,500
November 14,	497,700	523,900	325,000	575,100	442,400	226,100	183,900	40,000	389,600	98,782,200
November 21,	480,600	539,400	324,400	558,300	449,900	226,700	169,300	44,600	302,600	97,160,500
November 28,	478,600	519,200	316,900	557,600	434,700	222,400	178,300	40,000	293,300	98,141,800
December 5,	456,900	522,700	313,800	594,300	400,900	223,700	187,700	48,100	340,700	103,673,800
December 12,	479,000	518,300	268,600	584,400	431,800	209,100	176,700	56,900	327,000	101,280,900
December 19,	493,400	542,900	263,400	641,300	484,600	217,700	183,700	42,500	313,100	110,402,900
December 26,	438,000	572,600	262,400	657,200	453,700	203,900	194,800	41,100	362,200	110,977,600
January 2,	515,600	709,400	261,200	741,800	491,600	222,700	170,800	83,300	355,500	120,586,300
Average gallons per day, . .	531,600	619,000	325,300	667,900	467,400	227,800	242,700	137,500	527,300	101,324,500

MOSQUITOES AND SUGGESTIONS FOR THEIR EXTERMINATION.*

BY WILLIAM LYMAN UNDERWOOD, LECTURER IN THE MASSACHU-
SETTS INSTITUTE OF TECHNOLOGY.

[Presented January 13, 1904.]

The statement has been frequently made of late that there is no more reason why we should suffer from mosquitoes than there is that we should allow rats and mice to continually annoy us, and this statement is in a measure true. Rats and mice are to a great extent effectively held in check, for we have become accustomed to them and their habits, and we know how to deal with them. Were it not for the fact that a constant warfare is being waged against them, they would soon overrun our houses and make life unbearable.

In order to fight the mosquitoes successfully it is important that every one should take an interest in the popular uprising against this insect pest. And now that it is known that, besides being a nuisance, mosquitoes may be a menace to the health of the community, it is equally necessary that every one should become familiar with all that pertains to their life history, so that the war against them may be successfully and intelligently carried on. Notwithstanding all that has been written on the subject of mosquitoes during the last year or two, the majority of people still know but little about them.

It is the purpose of this article to state, in as simple a manner as possible, the facts that are now known regarding mosquitoes and how to deal with these pests, and it is hoped that this information may help to secure a more general coöperation in the work of mosquito extermination.

Few people realize that there are a great many different kinds

* Illustrated with photographs from life by the author. The article and the photographs are copyrighted.

of mosquitoes. Some 300 species have already been described, and here in the United States we have about 50 species, belonging to nine different genera. The most common of these genera in the northern states are *Anopheles*, the malarial, and *Culex*, the ordinary, mosquito. Of the former there are two species and of the latter at least fifteen.

Only these two genera and the methods for their extermination will be especially considered, and as these methods may also be successfully applied to the other kinds of mosquitoes, no detailed description of the others need be given.

It is commonly and quite naturally thought that mosquitoes breed in wet grass, as they are often seen to rise from it in clouds when disturbed, particularly in the early morning and evening. They have not bred there, however, but have merely sought the shelter of the grass where they can be protected from the wind. The moisture of the dew upon the grass also furnishes an attraction for them and they always prefer damp rather than dry places.

Another popular theory is that mosquitoes will breed *only* in foul or stagnant water. This is also a mistaken idea, though they often do breed in such water, not because it is impure or stagnant, however, but because these places are usually quiet, and here the female can deposit her eggs undisturbed.

It is commonly supposed that mosquitoes do not breed in salt water, but the recent "Mosquito Investigations" of Prof. John B. Smith, of New Jersey, which were published in the New Jersey Agricultural College Experiment Station Report of November, 1902, show that the larvæ of *Culex sollicitans*, the "Salt marsh mosquito," not only prefer salt or brackish water, but are seldom found in pools where the water is strictly fresh, and, contrary to the usual custom, this mosquito lays its eggs upon the soil of marsh or meadow land. There the eggs remain until the advent of an unusually high tide. Then after a few hours when the water has covered them, the infant larvæ make their appearance.

It is very generally believed that mosquitoes bite but once and then die. This is sometimes so; but, unless they are killed in the act of biting, they usually live to bite again. The female mosquito (for it is only the female that attacks human beings) bites many times. It is owing to this fact that *Anopheles* is able to



Fig. 1. — Mosquito "wrigglers" —larvæ and pupæ — in the water. Life size.

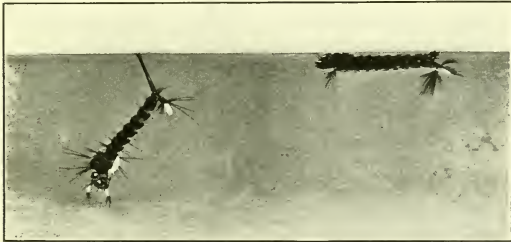


Fig. 2. — Mosquito "wrigglers" (larvæ) in the water. *Anopheles* larva to the right. *Culex* larva to the left. Three times as large as life.



Fig 3. — A pupa, the third stage in a mosquito's life. Three times as large as life.

convey the germs of malarial fever from person to person. When biting any one who is afflicted with malaria, the insect draws in with the blood the germs of the disease, which it afterwards carries on into the blood of another victim. The vast majority of mosquitoes never get human blood for food. In its absence they live upon the blood of birds and other animals, and when these are not to be found, upon the juices of young and tender plants.

It is not known just how long mosquitoes can live, but their average life is much longer than is ordinarily supposed. Thousands of them live through winter, hibernating or asleep in dark places in barns or house cellars. In sparsely settled localities, where they cannot find such places for shelter, they live through the winter in hollow trees, in caves and holes under up-turned trees; and, even though the temperature may fall far below freezing, they are not winter-killed, but on the approach of warm weather become active again. Mosquitoes are frequently seen flying about in the woods before the snow has wholly left the ground.

Mosquitoes cannot develop or come to maturity without water in which to live during the first weeks of their "wiggler" existence.

A mosquito's life is divided into four stages — the egg, the larva, the pupa, and the adult insect. In the larval and pupal stages, mosquitoes are more commonly known as "wigglers" (see Fig. 1, Plate I). Both *Anopheles*, the malarial, and *Culex*, the common, mosquito larvæ are present in this picture. Mosquito "wigglers" may frequently be found in rain-water barrels in as large numbers as are seen in this photograph. The female mosquito lays from one hundred and fifty to four hundred eggs upon the surface of some quiet water, and in a day or two these eggs develop into the larval or second stage (see Fig. 2, Plate I).

It will be noticed that *Culex* hangs with its head down, and from its tail upward to the surface of the water extends a small tube. Through this tube it breathes. *Anopheles* rests just beneath and parallel to the surface of the water, and its breathing tube is much shorter than that of *Culex*. These resting positions are quite different, and each is characteristic of its kind. Except

when disturbed, *Anopheles* is generally to be found at the surface, breathing and feeding in this position. *Culex*, on the other hand, comes to the surface only occasionally to breathe. It stays below the water for the greater part of the time, and is often found feeding from the bottom.

At the end of a few days the larvæ change into the pupal or third stage (see Fig. 3, Plate I). To the left is seen the larval skin out of which this pupa has just come. The difference between *Culex* and *Anopheles* in this, the final stage of "wiggler" existence, is very slight. Both now live at the surface of the water, and they breathe through two funnel-shaped tubes situated one on each side of the thorax, or "head." Unless disturbed they remain motionless in this position at the surface until the time comes when, as adult mosquitoes, they leave the water (see Fig. 1, Plate II). This is the critical period of a mosquito's life; for, should the surface of the water be disturbed at this time, the insect would be upset and drowned. It takes about seven minutes from the time when the skin along the back of the pupa begins to split until the full-grown mosquito comes forth, and in a few minutes is ready to fly away. A mosquito never grows any larger after this change.

The length of time required to pass from the egg to the adult insect varies from ten days to three weeks, according to the temperature. Warm weather hastens their development, while low temperature checks it. The "wigglers" of some species of mosquitoes live through the coldest weather of our northern winters unharmed, ready, when the first warm days of spring have come, to complete their natural changes.

Mosquitoes' eggs are so very small that ordinarily they remain unnoticed, but nearly every one who lives in the country is familiar with the little "wigglers" that are often seen squirming up and down in rain-water barrels. Few people know that these little fellows are connected in any way with mosquitoes, but it is a very easy matter to prove that they are. Let any one who doubts this fact dip up a few in a glass jar or tumbler and place them in the house, where they can be frequently looked at. Seeing is believing; and after a full-grown mosquito has once been seen to come forth from a pupa (which is the last stage of the

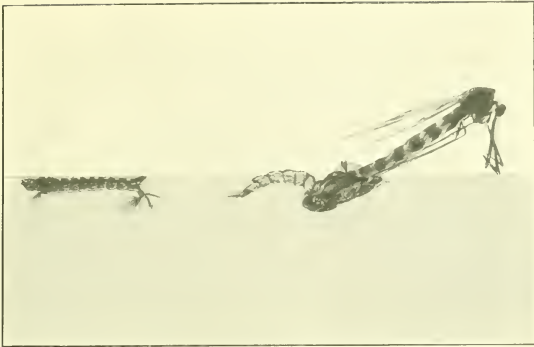


Fig. 1. — An adult mosquito (*Anopheles*) transforming from a pupa and coming out of the water. Three times as large as life.



Fig. 2. — Three times as large as life.

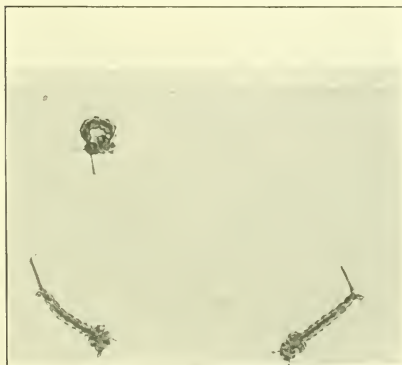


Fig. 3. — Three times as large as life.

"wiggler"), there can no longer be any question as to what these "wigglers" really are.

Most of the mosquitoes that annoy us are bred near by, often, though unknown to us, in our own dooryards. Any water that is accessible to mosquitoes and whose surface is undisturbed by winds or rapid currents furnishes a breeding-place for them, and "wigglers" may often be found in water standing in old tin cans or bottles, in rain-water barrels, in pools in the rocks, in roof or street gutters that are not properly drained, in cesspools or in catch-basins, in fact, in any place that will hold water for a week or two, no matter how small the quantity, even if only a few teaspoonfuls.

Since we know that without water mosquitoes in their first stages cannot exist, it naturally follows that all standing water should be done away with, or treated in such a manner that "wigglers" cannot live in it nor mosquitoes get to it to lay their eggs. To this end all cans, bottles, and every discarded utensil that will hold water should be removed. All stagnant pools, where it is possible to do so, should be drained or filled up. Cisterns, rain-water barrels, and cesspools should be screened or otherwise covered to prevent the adult insects from having access to them. Where it is not practicable to fill, drain, or screen the places that are suitable for mosquitoes to breed in, the surface of the water may be covered with kerosene oil. This oil, when spread over the water, prevents the "wigglers" from getting air when they come to the surface to breathe, and so kills them (see Figs. 2 and 3, Plate II).

In Fig. 2, Plate II, a "wiggler" is seen trying to get air, vainly thrusting its breathing tube up into the film of kerosene.

In Fig. 3, Plate II, the upper "wiggler" is grasping its breathing tube in its mouth, apparently trying to pull off the small particles of kerosene with which the tube has been clogged. The "wigglers" upon the bottom have been suffocated and have given up the fight.

An ounce (two tablespoonfuls) of kerosene will spread over fifteen square feet of water surface, forming a film thick enough to kill all the "wigglers" that are beneath it. Kerosene of a cheap quality, known as high-test light fuel oil, is preferable for

this purpose. It can usually be bought at eight cents a gallon. If oil of this quality is not available, ordinary kerosene will answer the purpose. It should be applied as often as once in two weeks, for by that time the previous application will have evaporated. A sufficient quantity should be used, in the proportions named, to cover completely any place that may need treatment.

Any one who is ill with malaria or yellow fever should be carefully protected from mosquitoes, for, should a person be bitten by an *Anopheles*, the malarial mosquito, or *Stegomyia fasciata*, the yellow fever mosquito, at this time, there would be great danger that the insects might fly away and bite some one else and thus spread these diseases. Screens for both doors and windows form the best protection against mosquitoes at all times; but it often happens that the insects get into our houses, even though they are thoroughly screened, generally through some door or window that has been left open by mistake, or they may gain an entrance by coming down an unused chimney if the flue is allowed to remain open during the summer time. A house or a room may be cleared of mosquitoes by burning pyrethrum powder and allowing the smoke, which is not at all offensive to most people, thoroughly to fill the room that is under treatment. This smoke kills or so stupefies the insects that they will not bite. Pyrethrum powder is a preparation of the plant *Pyrethrum roseum*, and is sometimes sold as Persian Insect Powder or Dalmatian Powder; it can be bought at any drug store for about thirty-five cents a pound. It is a very fine, light powder, and an ounce of it will go a long way, making a large volume of smoke. A pyrethrum smudge or smoke may be started by covering a live coal, taken from the kitchen stove, with the powder, first placing the coal upon a small shovel, so that it may be moved about conveniently without danger of setting anything on fire. The pyrethrum will quickly begin to smoulder and give off a dense smoke. All that is now necessary is to add from time to time a pinch of the powder as occasion requires, merely keeping the smouldering ashes covered so that they will give off a smoke. People are frequently annoyed and sometimes driven into their houses on summer evenings by the persistent attacks of mosquitoes. On such occasions, pyrethrum powder can often be

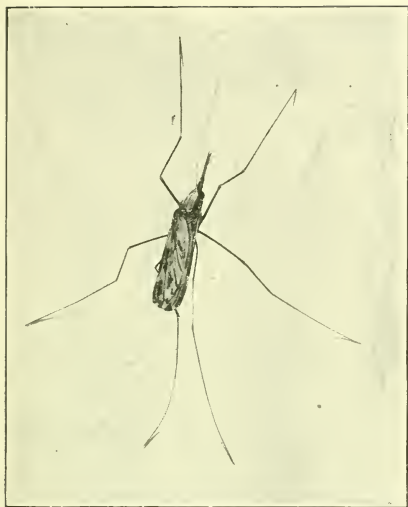


Fig. 1.—*Anopheles punctipennis* (female). Three times as large as life.

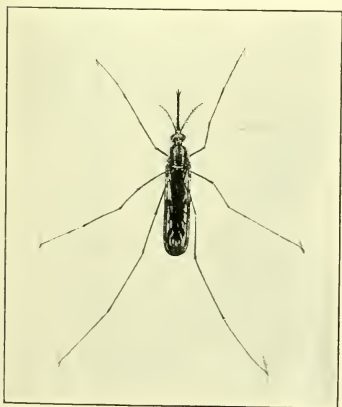


Fig. 2.—*Anopheles maculipennis* (female). Three times larger than life.



Fig. 3.—Profile of *Anopheles punctipennis* (female). Three times as large as life. Showing the characteristic resting position of this mosquito.



Fig. 4.—Profile of a *Culex* mosquito (female). Three times as large as life.



Fig 5.—Profile of a male *Culex* mosquito. Three times as large as life.

used to advantage; and the smoke from a small quantity of the powder kept smouldering on the piazza will drive away most, if not all, of the pests, thus making it possible to enjoy an evening out of doors in comfort, when otherwise life would be unbearable except behind the protection of screens.

The *Anopheles*, or malarial mosquitoes, though not very common (see Figs. 1, 2, and 3, Plate III), are breeding quite abundantly in many parts of this country; and by referring to the accompanying photographs, particularly the ones in profile, it will be seen that there is quite a difference between the malarial and the common, or *Culex*, mosquitoes.

Anopheles may easily be distinguished from the common or *Culex* family of mosquitoes by the spots upon their wings, and also by the position which they take when at rest (see Fig. 3, Plate III).

Notice the angle at which the insect shown in Fig. 3 stands out from the wall. Compare this with Fig. 4, Plate III. It will also be seen that the proboscis, or "stinger," and the body of *Anopheles* form a straight line, while the *Culex* is rather humpbacked. The other *Anopheles maculipennis* does not stand out from the wall at quite such an angle as does *punctipennis*; but like the latter its proboscis and body form a straight line, and the angle formed by the insect when at rest is much greater than that of the *Culex*.

Notice how different is the resting position of the mosquito in Fig. 4 from that of *Anopheles* in Fig. 3, Plate III.

The male mosquito (see Fig. 5, Plate III) never bites. He may be easily distinguished by his large and feathered antennæ and palpi, which are very much more prominent than those of the female.

There is another mosquito, *Stegomyia fasciata*, which in form and habits closely resembles *Culex*, in which genus, until quite recently, it was classed. *Stegomyia fasciata* is the yellow fever mosquito, and it inhabits only the warmer portions of this country. It is common in most of our southern states, and is seldom seen north of the Carolinas. It is easily distinguished from other mosquitoes by the conspicuous silvery white stripes upon its thorax and abdomen, and by the white bands upon its legs.

Fortunately for mankind, nature herself provides many energetic workers which are constantly doing their part towards hold-

ing in check these insect pests. Foremost among these natural enemies are many of the insectivorous birds, which daily destroy many thousands of mosquitoes. The swallows, the fly-catchers, the night-hawks, and the whip-poor-wills, all are insect exterminators, whose good work in this connection is seldom taken into account. The bat is also an efficient mosquito hunter; so, too, are the dragon flies which frequent the shores of ponds and pools where mosquitoes breed.

Besides these enemies of the adult mosquito, which may properly be called their "foes of the air," mosquitoes have other adversaries which destroy them in their early stages. These may be termed their "foes of the water."

It often happens that we can find no "wigglers" in small ponds in which we would naturally expect to find mosquitoes breeding. In such ponds the presence of fish may account for the absence of mosquitoes. Their larvæ furnish food for many species of our smaller fishes, and by them myriads of mosquitoes are annually destroyed. Goldfish are particularly fond of mosquito "wigglers," and the pair of fish in the illustration (see Fig. 1, Plate IV) were seen to eat ninety-eight "wigglers" in four minutes. Goldfish will live and multiply in almost any small and shallow pond in this vicinity, where the water is warm. They are perfectly hardy and will thrive just as well and perhaps better in stagnant water than they will in flowing streams.

The "top minnow," the roach, the sunfish or "pumpkin seed," and even the sluggish hornpout, all play an important part in reducing the numbers of mosquito "wigglers." Besides the fishes, there are other "foes of the water" that prey upon mosquito larvæ. Many of the predatory water bugs feed upon them. Prof. J. B. Smith, in the report previously referred to, says that "among these predatory insects which abound in shallow, permanent bodies of water wherever there is vegetation, the water boatman (*Corisa* and *Notonecta*), the water striders or 'skate bugs' (*Hydrobatidæ*) and the water scorpions (*Nepidæ belostomatidæ*) deserve mention." He also speaks of the "water tiger," the larva of the large water beetle (*Dytiscus*), and tells of its ability to clear *Culex* larvæ from pools of water.

In this connection a brief description of a newly discovered

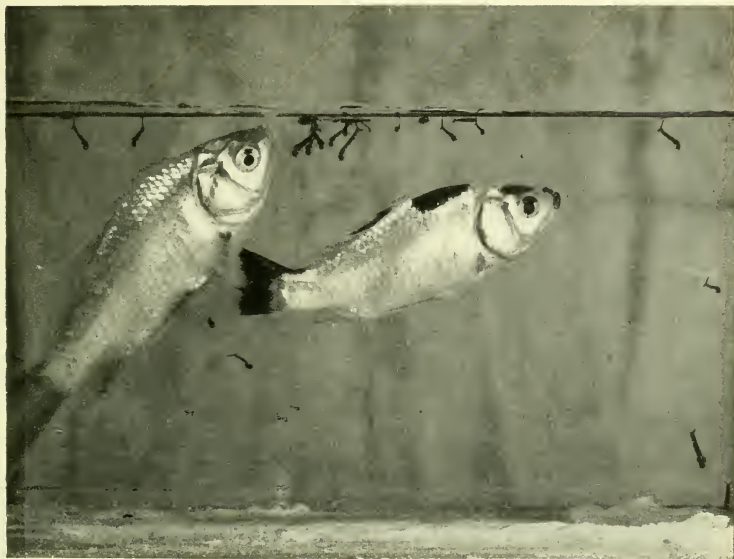


Fig. 1. — Goldfish eating mosquito larvæ. Life size. These two fish were seen to eat ninety-eight "wigglers" in four minutes. They always fed upon mosquito larvæ when they could get them in preference to prepared goldfish food.

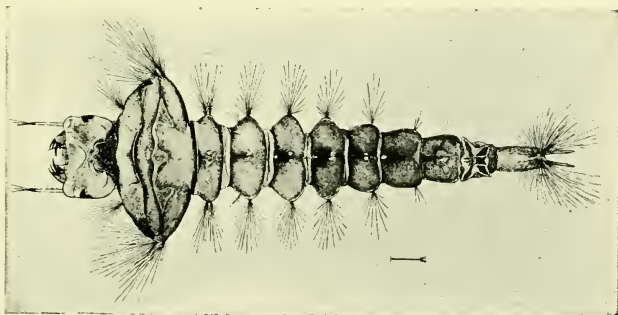


Fig. 2. — Larva *Eucorethra underwoodi*. Dorsal view. Original drawing. Six times as large as life.

mosquito,* to which has been given the name *Eucorethra underwoodi*, should be of interest, since it has been found that their larvæ devour the wigglers of other mosquitoes, and unlike other mosquitoes, the adult female insect does not bite. As the proboscis of this insect is so formed that it cannot puncture the skin, it should not perhaps be called a true mosquito, though it has been classed as one, since it belongs to the family *Culicidæ*.

The larvæ of this insect were found by the author on January 27, 1903, in the Maine woods in the eastern section of Penobscot County, and were discovered in a spring of water from which a crew of lumbermen were getting their water supply. A few days later, other larvæ of the same species were found in a similar spring about eight miles distant, though in this case, as the spring was not in use, its surface was covered with a coating of ice an inch thick. The temperature of the water at the bottom (it was about two feet deep) was 42° F.

At first sight this larva would be taken for an *Anopheles* of extraordinary size, as it is of the same general shape, and when the water was cleared of ice, it lay just beneath and parallel to the surface, breathing through a short respiratory siphon, as is characteristic of the larvæ of *Anopheles*. In this spring a barrel had been sunk, and in the fifty gallons, or thereabouts, of water which it contained, there were twenty-five larvæ. They were all of about the same size — 12 to 14 mm. long — and almost black in color. All were secured and taken into camp for further investigation.

Close observation of the larvæ showed that besides being much larger (12 to 14 mm. long instead of 5 to 7 mm.), they differed in many other particulars from the larvæ of *Anopheles* (see Fig. 2, Plate IV). In proportion to the rest of its body, its head is larger than the head of *Anopheles*. It does not turn its head upside down when feeding as does *Anopheles*. Its mandibles are strikingly large and powerful, and are prominently toothed. It lacks the frontal tufts or brushes which are conspicuously present in *Anopheles*, and its antennæ, which extend directly forward parallel with the sides of the head, are much longer and more slender, and are tipped

* Under the title "A New Mosquito" a description of this mosquito appeared in *Science*, August 7, New Series, Vol. XVII, No. 449.

each with three hairs of equal size. The thorax is broadly elliptical, and is much wider in comparison with its abdominal segments than is the thorax of *Anopheles*. The sides of the thorax and the abdominal segments bear fan-shaped tufts of hairs, not plumose as in *Anopheles*. The tufts on the last segments, both dorsal and ventral (see Fig. 1, Plate V), are more profuse in *Eucorethra* than in *Anopheles*, especially the ventral tuft, which in *Eucorethra* occupies nearly the whole segment. Only two anal papillæ are present, while *Anopheles* has four.

A few days before the author returned to Boston, several larvæ died and three changed to pupæ. The pupa resembles that of *Culex* (see Fig. 2, Plate V), rather than of *Anopheles*, and its respiratory siphons are of the same shape as those of *Culex*. When stretched out at full length, the pupa measures 10 mm.

On reaching home, the new wigglers, eighteen in number, were put into a quart jar which was placed near a window where it would receive the sunlight for two hours each morning. The temperature of the water now averaged about 70° F., and with this change the larvæ developed a new trait,— they began to eat each other up. The act was witnessed on several occasions. The larva would grasp its adversary just forward of the respiratory siphon with its powerful mouth parts, and working the tail in first, it would gradually swallow its victim, shaking it now and then as a terrier would shake a rat.

After losing many of the insects in this way, those that remained were separated, and each individual was placed in a small bottle by itself. Eventually, I succeeded in rearing a number of males and females. The pupal stage of this insect varies from five days and nine hours to six days and ten hours. The adult (see Fig. 3, Plate V), resembles *Anopheles* in having maculated or spotted wings, but is much larger and measures eleven millimeters in length. Its mouth parts, however, are not adapted for biting. A full description of the imago is soon to be recorded by Mr. D. W. Coquillett, of the National Museum, by whom the name above mentioned was given.

During a visit to Maine in June, a large number of larvæ of *Eucorethra* were taken from the spring where the barrel had been sunk. It was noticeable that larvæ of other kinds of mosquitoes



Fig. 1. — Last segment of larva profile. Original drawing. Six times as large as life.



Fig. 2. — Pupa *Eucorethra underwoodi*. Original drawing. About eight times as large as life.

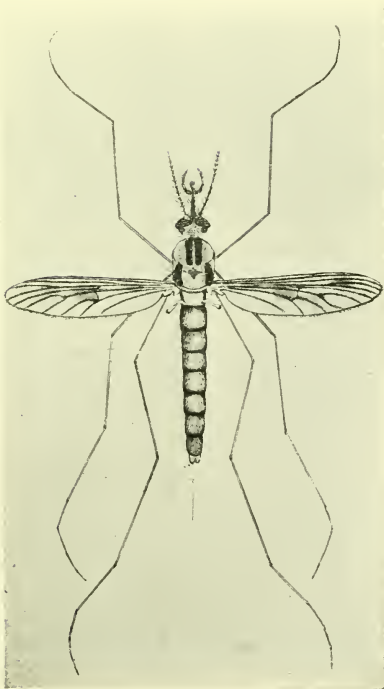


Fig. 3. — *Eucorethra underwoodi*. Coquillett MS. Original drawing. Four times as large as life.

were absent, although the adults were very numerous in the immediate vicinity.

The absence of other mosquito larvæ was accounted for when later it was discovered that the larvæ of *Eucorethra* fed upon the larvæ of other mosquitoes, eating them apparently with great relish. On several occasions fourteen *Eucorethra* larvæ ate, during the night, sixty *Culex* larvæ out of the seventy that had been placed in the water with them. When eating the larvæ of mosquitoes smaller than themselves, the victim is caught, shaken violently a few times, and swallowed in a few seconds in very much the same way that a pickerel would catch and swallow a smaller fish.

As yet no experiments have been made to see if this new species will devour the larvæ of *Anopheles* as readily as they will those of *Culex*. Whether or not this species will thrive in the climate of southern New England is as yet uncertain, but experiments are now being carried on to determine this point.

Although myriads of mosquitoes are destroyed by the natural enemies which have been mentioned, *man should* be the most destructive foe of these insects. There is no doubt that the mosquito pest may be very largely abated by the employment of scientific methods for causing its destruction in the early stages of its development.

While it is the duty of boards of health to recognize mosquitoes as active agencies for the dissemination of certain diseases and to take such measures as are possible for their extermination, the work can never be effectively done until the people of each community are fully informed in regard to the life history of the mosquito, so that all may coöperate intelligently to secure its destruction.

DISCUSSION.

MR. FREEMAN C. COFFIN.* I should like to ask a question. We understand that in the economy of nature there is a use for everything, and I should like to ask the speaker of what use are mosquitoes.

* Civil Engineer, Boston, Mass.

MR. UNDERWOOD. I think it is generally understood that there is a use for everything in the economy of Nature, but the only thing I can see that mosquitoes are of use for is as food for ducks and fish, and as ducks and fish are eaten by us, perhaps in a round-about way mosquitoes may be of some use to us; but I think I would risk losing my fish and ducks in order to be freed from the mosquitoes. I don't think they are of any use.

MR. ROBERT J. THOMAS.* I should like to ask if tobacco smoke will drive mosquitoes away?

MR. UNDERWOOD. Tobacco and cigar smoke does have a very good effect. I think if you were to burn tobacco on the piazza in the same way that you do pyrethrum powder it would possibly be more effective in driving the mosquitoes away. All of us who smoke know that mosquitoes keep away from us if we are smoking, but tobacco smoke is not pleasant to some people. When collecting mosquitoes in the woods, I have a little glass jar with me and I put it over a mosquito when it is biting, and then puff a little tobacco smoke into the jar and in a very few minutes the mosquito is dead.

MR. FRANK L. FULLER.† I would like to inquire as to the quantity of kerosene oil needed per acre.

MR. UNDERWOOD. I am not a very good mathematician. An ounce of oil will cover 15 square feet, and from that you can figure how much it will take for an acre. In the photograph I showed you of course the oil was very much thicker than would have to be used, but, as I say, an ounce to 15 square feet, although it will not make a very deep film, will be enough. You know that if you put a few drops of oil on water you will see a blue film, and wherever you see that film you won't see any mosquitoes. I am told that in the oil fields of Pennsylvania years ago, before oil was discovered, there were a great many mosquitoes, and it is said that now around the oil fields they never have any. The pools of water are all covered with a film of oil and the mosquitoes cannot breed in them. I am told this by people who have lived there, and while it may not be true it seems very natural to me that it should be so.

* Superintendent of Water Works, Lowell, Mass.

† Civil Engineer, Boston, Mass.

MR. HARRISON P. EDDY.* In connection with some experiments with sewage last summer I had a tank about 10 feet long, 3 feet wide, and 6 feet deep, which was filled with sewage. This was agitated violently about half an hour at a time four times a day, and the surface of the water was entirely covered with a film of oil, quite a thick film, so thick that if you dipped a pencil into it the pencil showed the traces of the oil. Mosquitoes bred there very rapidly, and did not seem to be affected either by the oil or by the agitation. Now, I would like to ask if the two remedies which Mr. Underwood has told us of are always unfailing?

MR. UNDERWOOD. How did the water get into the tank? Did it come from the sewer?

MR. EDDY. Right from the sewer. It was an experimental tank and was connected with the main trunk sewer.

MR. UNDERWOOD. And the oil was put on to keep the mosquitoes away?

MR. EDDY. No; the oil was a natural oil which came to the surface of the sewage. The tank was exposed to the sun, and probably a temperature of about 70 degrees was maintained during the daytime.

MR. UNDERWOOD. You might account for the mosquitoes coming there. The agitation itself would not prevent them. In the hour or two which intervened between one agitation and another a good many hundred mosquitoes could deposit their eggs, and the agitation afterwards would not hurt the eggs or the wigglers. If the agitation occurred about the time the pupæ were going to split and the adults come out, it would kill the mosquitoes. The oil was not kerosene, and it depends upon the kind of oil. Kerosene oil and one other oil, I don't at the moment remember what it is, are mosquito exterminators, but I think a large majority of oils would not have any effect in killing them.

MR. S. A. AGNEW. How often is it necessary to treat the pools with oil?

MR. UNDERWOOD. They should be treated on an average of every two weeks. The average length of time from the egg to the adult, as I said, in very warm weather is about ten days, and it is the rule to treat the pools about every two weeks; that has

* Superintendent of Sewers, Worcester, Mass.

been found to be effective. I would suggest to Mr. Eddy that if his experiments are carried on another summer, if he will put kerosene oil upon the tank I think he will find that he will not have any mosquitoes there, unless the agitation should be so violent as to carry the oil down into the water or cause it to evaporate or something of that kind. It seems to me that if kerosene oil were put on it would not be possible for mosquitoes to breed there.

MR. EDDY. It occurred to me whether the agitation wouldn't give them sufficient oxygen.

MR. UNDERWOOD. I think it might well be so.

MR. EDDY. The water was violently agitated for periods of half an hour, compressed air being used under a pressure of five or six pounds.

MR. UNDERWOOD. I think that might have a very decided effect; perhaps, would give them enough oxygen even if kerosene were used upon the surface.

MR. F. W. DEAN.* Mr. Underwood spoke about the natural enemies of mosquitoes, and I would ask him if he is aware of the effect of the plant called sun-dew as a destroyer of mosquitoes?

MR. UNDERWOOD. I have heard about it but I am not familiar with it.

MR. DEAN. I don't know whether the plant grows about here or not, but in 1881 and 1882 I was on the island of Campobello off Eastport, Maine, and Professor Shaler was concerned in the survey also. He discovered that the sun-dew grew in Campobello in considerable quantities, and the Professor being quite original, as you know, and bringing mathematics and other sciences to his aid as may seem desirable, made an estimate of the number of patches of sun-dew there were on the island and the number of dead mosquitoes he found on the plants, and he figured up that in a year 365 000 000 mosquitoes were killed on the island of Campobello by the sun-dew.

MR. UNDERWOOD. You have probably noticed, if you have been at Campobello at certain seasons of the year, that there are plenty of them left.

MR. FULLER. I should like to ask Mr. Underwood how it is

* Mechanical Engineer, Boston, Mass.

that some years there seem to be a great many more mosquitoes than there are other years. At my house this last summer we were very much troubled with them. There was no stagnant water and there were no pools of water anywhere about, and I don't know of any tin cans or anything of that kind lying around to hold water, and yet it seemed to me that we had ten times as many mosquitoes last summer as we ever had before. I would like to get some idea what the cause might have been.

MR. UNDERWOOD. The conditions last summer were very favorable for mosquitoes and unfavorable for us. We had periods of rain in June which extended for a long while, which made more than the average number of puddles for mosquitoes to breed in. After that we had very warm weather for quite a long while and the eggs which had been deposited in these puddles came to maturity, and we had swarms of them all over this eastern section of the country. It was merely that the weather conditions were just right last summer for the breeding of mosquitoes. Of course, in an exceptionally dry summer we won't have many mosquitoes, because the pools will dry up, but last summer conditions were just right for them. Mosquitoes will travel quite long distances under certain conditions, where a prevailing wind is blowing, not violently but rather moderately, for many hours. Mosquitoes have been known to travel under those conditions 20 or 30 miles. Vessels coming in towards the Jersey coast will meet the typical Jersey mosquito that distance out at sea.

MR. AGNEW. Have you ever heard of the castor bean being used to drive away mosquitoes?

MR. UNDERWOOD. I have read of it.

MR. AGNEW. I have lived in the South a good many years, in the south of Florida, where they are troubled with a great many mosquitoes, and it was a practice among the natives there to use the castor bean to drive away mosquitoes. Personally I never saw that it did any good, but I know it was used by the natives.

MR. UNDERWOOD. Castor oil is very effective.

MR. AGNEW. This was the castor bean just as it grows.

MR. UNDERWOOD. I don't know about the castor bean, but I know that castor oil is effective.

SOME NOTES ON COST OF WATERPROOFING THE CONCRETE LINING OF RESERVOIRS.

BY W. C. HAWLEY, CHIEF ENGINEER AND GENERAL SUPERIN-
TENDENT PENNSYLVANIA WATER COMPANY, WILKINSBURG, PA.

[Read January 13, 1904.]

Concrete has been very commonly used for lining reservoirs for the storage of water. For this purpose it is laid like a pavement, generally about six or eight inches thick, on a layer of puddle. The concrete is usually of good quality and the top surface, from one-half to one inch thick, is a rich mortar, carefully troweled and ironed. This gives a clean, hard, durable surface, of good color and appearance, but it is not waterproof, and for this quality dependence is put upon the puddle. To prevent leakage, the concrete is sometimes given a coating of asphalt or other impervious material; but this is not making the concrete waterproof, but preventing the water from coming in contact with the concrete. It is a very expensive operation and renders the reservoir unsightly, especially if, as frequently happens, the heat of the sun causes the asphalt to soften and run.

Concrete is made up of a mixture of various quantities of broken stone or gravel, sand, and cement. The theory of the mixture is that the finer particles fill in the voids between those that are coarser, and by a proper mixture a practically solid mass results. The limit is the degree of fineness to which the cement is ground. Experiment has shown that by great care small amounts of concrete can be made which are practically impermeable, but it is not possible to make concrete in large amounts which shall all be waterproof; and even if it could be one, it would be too expensive.

What is needed is some way of filling the minute spaces which allow the water to pass through the concrete. If the leakage will not endanger the stability of the reservoir, and the value of

the water in the reservoir is small, the loss may be permitted, and the concrete may ultimately become tight by retaining the silt or solid matter which is filtered out of the water which passes through.

The United States Government has, in recent years, used linseed oil to render concrete waterproof. The surface of the concrete is cleaned and must be dry. Two coats of linseed oil are then applied, the second after the first has dried. The oil soaks into the concrete, and, upon oxidizing, it fills the voids and renders the concrete waterproof. This is an expensive process, however, and its lasting qualities are yet to be proved.

The oldest and probably the most satisfactory means of rendering concrete (or other masonry) waterproof is what is known as the Sylvester process, and consists of applying a wash of a solution of soap, which is allowed to soak into the surface of the concrete, and is then followed by a wash of a solution of alum. The soap enters the voids of the concrete and is followed by the alum. Where these two unite the chemical action precipitates an insoluble compound, which fills the voids in the concrete and renders it impermeable. It is this method and some variations of it to which this paper would call attention.

In a paper read before the American Society of Civil Engineers, in May, 1870, Mr. William L. Dearborn described the use of Sylvester's soap and alum process as used for waterproofing some of the walls of the gate houses of the Croton Reservoir in Central Park, New York City. This work had been done in 1863, and the results obtained are stated to have been entirely satisfactory.

It seems strange that so simple a process should have been known for so many years and should not have come into more general use. Possibly the cost of doing the work, which is stated to have been 10.06 cents per square foot, has deterred others from using it. In view of the cost of some recent work of this kind, it would be interesting to know what the materials cost in 1863, and how it was possible to spend ten cents per square foot. The process is now coming into very general use, and its cost and the cost of some modifications of it may prove of interest.

About a year ago the Apollo Water Works Company constructed a slow sand filtration plant. The water, after being fil-

tered, passed into a covered concrete clear water well or reservoir, which, after completion, was found to leak. Mr. Edward Cunningham, the assistant engineer in charge of construction, conceived the idea of making it water tight by plastering the inside surfaces with a mortar in which the soap and alum were mixed. The soap — a light-colored soft soap — was dissolved in the water in a proportion of one and a quarter pounds of soap to fifteen gallons of water. Three pounds of powdered alum were added to and mixed with each bag of cement. The mortar was mixed in the proportion of two parts of sand and one of cement, and moistened with the water in which the soap had been dissolved. Two coats of plaster were applied, with a total thickness of about one-half inch. Adding soap and alum improved the working qualities of the mortar, and the only difficulty experienced was on account of the intensely disagreeable odor while the mortar was being applied. This nauseated the masons occasionally, but did not last but a few days. It was probably caused by the quality of soap used and because the work was done in an enclosed space. The mortar was applied when the walls were dry, and the results were entirely satisfactory. The walls which leaked badly before have been to all appearances perfectly tight since.

The cost of this waterproofing in a one to two mixture was as follows:

Soap, 2 pounds (with 24 gallons of water)	@	\$0.07½	\$0.15
Alum 12 pounds	@	.03½	.42
Total, per barrel of Portland cement used .			\$0.57

By purchasing in larger lots and a cheaper grade of soap, this cost could probably be reduced to from forty to forty-five cents per barrel of cement used.

The question might be asked, "What effect does the soap and alum have upon the setting and strength of the cement?" This depends upon the amount of soap and alum used. The amounts used as above possibly delay the time of setting slightly. The alum would increase the strength of the cement, as shown by experiment, as much as 50 per cent. The soap would reduce the

strength of the cement slightly, and, if used in considerable quantity, would cause checking and cracking of the cement. Used together, it is doubtful if the strength of the cement is altered appreciably, as one acts chemically upon the other, thus neutralizing the effects of both.

A few months ago it became necessary to make some repairs to what is known as Reservoir No. 2 of the Pennsylvania Water Company, which is located back of Braddock. In the course of the work it was found that in places the concrete had been laid directly on the rock, which was a seamy shale, and that the concrete was of a poor quality, from four to six inches in thickness. It was deemed advisable to try to make this concrete waterproof, and the process was the "Sylvester" process, as described by Dearborn. The soap solution was made of what is called Olean soap, in a proportion of three fourths of a pound of soap to one gallon of water, and the alum solution was made of one half pound of alum and four gallons of water. Both the soap, and alum were perfectly dissolved, the soap solution being boiled in order to insure this result. The surface of the concrete was swept and scrubbed in places, and, after it was perfectly clean and dry, a wash of the soap solution was applied, it being put on at a boiling temperature. Twenty-four hours later this was followed with a wash of alum, and, after another twenty-four hours a second wash of soap, and twenty-four hours later a second wash of alum was applied. In applying these washes four sets of men were used, three men in each set. Two men applied the solution with white-wash brushes, while the third carried the solution to them in a pail. In making the soap solution it was necessary to have two men attend to the four kettles used to dissolve the soap, two men to carry the solution to the men using it, and one man to keep up the fires. The preparation of the alum solution did not require so many men, as it was only necessary to put the right amount of alum into a barrel of water and dissolve it, with occasional stirring. After applying the second wash of soap, it was found that the concrete on the slope was very slippery, and that the men could only work on it while being held by a rope secured to the top of the bank. The rope was placed around two men, and they started at the top of the bank applying the alum solution.

while the third man let out the rope, as was necessary to allow the others to work down the slope. The work was done in eight and a half days and cost as follows:

1 140 hours labor	@ \$0.15	\$171.00	
83 „ foreman	@ .30	24.90	
83 „ water-boy	@ .06	4.98	\$200.88
Add for superintendence, 15%,			30.13
Total for labor			\$231.01
900 pounds Olean soap	@ \$0.04 $\frac{1}{2}$	\$39.00	
210 „ Alum	@ .03	6.30	
6 10-inch whitewash brushes	@ 2.25	13.50	
6 stable brushes	@ 1.25	7.50	66.30
			\$297.31

The area covered was 131 634 square feet. Hence the cost of the two coats each of soap and alum was \$2.26 per thousand square feet.

When the reservoir was filled a slight leak developed, the water coming out below the outlet pipe. It is probably the leakage from a crack or cracks in the concrete lining, and it is slowly reducing in amount.

The concrete lining of a new reservoir which has just been completed near Wilmerding was waterproofed by using caustic potash and alum in the finishing coat. A stock solution was mixed, using two (2) pounds of caustic potash and five (5) pounds of powdered alum to ten (10) quarts of water. This was made up in barrel lots, from which three quarts were taken for each batch of mortar for the finishing coat. Each batch of mortar was made of two bags of cement mixed with twice the volume of sand, and covered an area about six feet wide by eight feet long, one inch deep.

The extra cost of waterproofing this concrete was as follows:

100 pounds caustic potash	@ \$0.10	\$10.00	
70 „ „ „	@ .09	6.30	
960 „ powdered alum @ .03 $\frac{1}{4}$, .03 $\frac{3}{4}$, and .04		34.38	
Cost of material			\$50.68
1 man mixing material 60 hours @	.15	\$9.00	
Freight, express and hauling		11.50	20.50
Total			\$71.18

The total area covered is 74 800 square feet, so that the cost of the work per thousand square feet was \$0.95, which shows that it is much less expensive to mix the alum and soap or potash with the mortar while laying the lining than it is to put it on with brush afterwards. The result obtained is also much better, as the waterproofing material extends all through the top coat, whereas if put on by brush, it only penetrates for perhaps a sixteenth or an eighth of an inch.

The addition of the waterproofing mixture gave the finishing coat a more compact appearance than it ordinarily has. It was found, however, that if less than two of sand to one of cement was used in the mortar, the finishing coat checked in setting. It was also found necessary to use only a clean sand, as any organic impurities soon decomposed and left soft spots on the surface where they had been.

Experiments show that care must be exercised to avoid using too much potash, as it not only has this effect on any organic matter which may be present, but it will cause checking or cracking of the finishing coat, and reduces the strength of the cement. A slight excess of alum, however, is not objectionable, as it increases the strength of the cement.

It was expected that the new reservoir would have been in service before this, but delays in getting a new pipe line laid have prevented. It is therefore impossible to state what results have actually been obtained. However, the lining appears to be perfect, and we have every reason to believe that the slight extra cost of the attempt to make the concrete waterproof has been a good investment.

DISCUSSION.

MR. J. WALDO SMITH.* This description of the different methods of rendering porous concrete water tight has been most interesting, but the writer is very strongly of the opinion that if concrete is mixed in proper proportions no waterproofing of any kind is necessary. But, in order to attain this result, the mixture should be properly balanced, and it should, also, in his opinion, be mixed very wet.

* Chief Engineer Croton Aqueduct Commission, New York City.

In work coming directly under his charge, he has had occasion, in the last few years, to use large quantities of concrete in places requiring absolute water tightness, and has not found any difficulty in achieving this result without the use of waterproofing.

The best example, perhaps, is the construction of the filtration works of the East Jersey Water Company, at Little Falls, N. J. In this plant the filter tanks proper are 24 feet long, 15 feet wide, and about 10 feet deep. The side walls of these tanks are 18 inches thick at the bottom and 6 inches at the top, and there is absolutely no percolation through the wall. The concrete used in its construction was mixed exceedingly wet, and these tanks also received a coat of plaster on the inside. The basin walls, having a head of 44 feet of water against them, are about 23 feet thick at the bottom and 2 at the top, and are composed of a mixture of one part Portland cement, three parts sand, and seven parts of broken stone, all mixed very wet, which has resulted in an impervious wall.

There is also in this plant a standpipe 44 feet high and 10 feet in diameter, composed entirely of concrete, with, of course, iron strengthening rods imbedded. The walls of this tank are 18 inches thick at the bottom and 12 inches thick at the top.

With a full head of water in this tank, 44 feet, the walls were tight, and, for the most part, perfectly dry on the outside.

From experience gained in the construction of this plant and in other works, it would appear that the most essential thing necessary to make water-tight concrete is to determine carefully the ingredients to be mixed and to use plenty of water in the mixture, and also be especially careful that all the voids are filled and the exterior surfaces left smooth.

MR. FRANK L. FULLER. I have had very good results from using simply a brush coat of pure cement, about the thickness of gruel, applied with a brush. It was inexpensive, and in a great many places has answered the purpose very well indeed. By putting on several coats it is possible, I think, to make a wall water tight. On the bottom of a reservoir I think, as is suggested in the paper, it is a good idea to have the upper surface composed of mortar, of perhaps two of sand to one of Portland cement, and then possibly a brush coat on top of that, although if the bottom

is of good material, I should hardly think a brush coat was necessary.

MR. EDWARD S. LARNED. I do not know that I can add anything to Mr. Smith's remarks on the imperviousness of well-made concrete. I quite agree with him that artificial measures are not necessary to make concrete water tight if proper care is used in the mixture, and it is of the right proportions. I think the results will be uniformly as satisfactory as he has stated. One of the greatest difficulties in making the concrete lining of a reservoir water tight, I believe, is the liability to expansion and contraction during the operation of placing the concrete; and some very interesting experiments have been made in connection with the Jerome Park Reservoir to overcome this difficulty, by covering the work until completed with wet cloths and sand. Owing to the magnitude of that work, of course it is very much more difficult to carry it through to a satisfactory completion than in the case of a smaller reservoir, but I think engineers will agree that some sort of protection is very necessary.

There is quite an interesting discussion of this topic in the August proceedings of the American Society, and the Sylvester wash is described there in some detail, together with several other expedients tried. One of the cement manufacturers has suggested a small addition of lime putty as being a very valuable aid to the impervious qualities of cement mortars. There is going to be more or less investigation of this subject, and I think we are quite in the way of knowing a good deal more about it in the very near future.

MR. W. C. HAWLEY (*by letter*). It was not the intention of the writer in presenting this paper to recommend the Sylvester process as the only method by which concrete can be made water tight. He agrees fully with Mr. Smith that with a properly balanced mixture, put into place very wet, the same end can be accomplished. Where the concrete is built up in vertical molds, this can and should be done, but in lining the slopes of a reservoir embankment, say 1 on $1\frac{1}{2}$ or 1 on 2, a very wet mixture cannot be used, and it becomes more difficult to secure imperviousness. On a reservoir bottom a wet concrete can be used, but it is a question whether or not the usual 6 or 8-inch layer will be water

tight under the 15 to 25 feet or greater heads to which such linings are often subjected. The alternative is either to use a thicker layer of concrete, with its extra cost, to say nothing of either extra excavation to allow for the extra thickness, or a sacrifice in capacity of reservoir, or else to use some waterproofing material. It seems evident, therefore, that if so simple a process as the one described in the paper can be applied for a cost approximating \$1.00 per thousand square feet, it is money well invested.

The brush coat of pure cement mentioned by Messrs. Smith and Fuller is a very efficient means of waterproofing, but the writer's experience with it is that it leaves a dull, rather rough appearing surface, instead of the fine, hard, smooth surface of the mortar containing proper proportions of soap or lye and alum. This would not be objectionable in a covered basin, though if more than one brush coat of cement were necessary, the soap and alum process — mixing them in concrete as it is made — would probably cost less.

One of the questions yet to be settled is, What are the best proportions of soap or lye and alum to be used? In determining this, not only must we keep in mind the effect of the mixture in making the concrete impervious, but also its effect on the strength of the concrete. The writer has recently made some experiments on the effect of the alum and lye on the tensile strength of Portland cement. Briquettes were of neat cement, and of 1 to 1, 1 to 2, and 1 to 3 mixtures of cement and sand. Nine briquettes of each kind were tested without the addition of lye or alum; 9 of each kind with the addition of alum to the amount of one per cent. of the weight of the cement, and lye (commercial caustic potash) to the amount of one sixth of one per cent. of the weight of the cement; and 9 of each kind with alum, two per cent., and lye one third of one per cent. Three briquettes of each set were broken in twenty-four hours, three in seven days, and three in twenty-eight days. The number of tests is, of course, too few to be conclusive, but the results show that the alum and lye have very little effect on the cement when used in these proportions, except to slightly delay its setting.

THE DETECTION AND PREVENTION OF WATER WASTE AT MARION, OHIO.

BY EDWARD H. COWAN, SUPERINTENDENT MARION CITY WATER
COMPANY.

[Read March 9, 1904.]

Marion is a rapidly growing little city, with a population, in 1890, of 8 327; in 1900, 11 862; and at the present time (1904), about 15 000. It is situated on the divide between the Mississippi and the St. Lawrence rivers, only a few miles from the line separating those two great watersheds. The city water supply is obtained partly from an impounding reservoir excavated through a stratum of clay into a water-bearing gravel; and partly from a series of ten 10-inch drilled wells, from 100 to 200 feet deep, reaching into the limestone formation which underlies the country around.

During the lawn sprinkling season of 1900, it was with the greatest difficulty that enough water could be obtained to supply the city. The water in the wells was so far below the level of the pumps, as they were then located, that only a small amount could be drawn from that source. The average daily consumption for the year 1900 was 825 692 gallons, or 1 290 gallons per tap. It was considered that this was excessive, and from that time on greater attention has been given to the detection and prevention of waste. It is the purpose of this paper to describe some of the methods used and results obtained.

It was thought that the greater part of the leakage was on the customers' side of the curb cocks, and subsequent events have shown that this view was correct. The installation of meters was decided upon, and has been going on ever since. The water works plant is owned by a private company, and under the terms of its franchise a customer has his choice whether he will pay fixture or meter rates, in the latter case furnishing and maintain-

ing his own meter. It is thus impossible to place a customer on a meter basis against his will, unless he be found wasting water, in which case the franchise provides that he may be required to buy a meter and pay meter rates, or his water may be shut off.

The policy adopted was, therefore, that the Water Company should place a meter on the service pipe of each fixture-rate customer who should continue paying the same rate as before, so long as the meter showed him not to be wasting water. A monthly allowance is made for each individual customer, and if he uses more than this amount a postal card notice is sent him, to the effect that his meter indicates a large waste of water, which must be stopped.

If at the end of the next month he is still using more than his allowance, the same notice is sent again, with the words "Second Notice" stamped across the face. At the end of the third month the following is stamped on the postal card: "Last Notice. We have already sent you several notices to this effect. If the amount used next month indicates a waste of water, you will be required to buy the meter and pay by the thousand gallons." At the end of the fourth month he is required to buy the meter as above, and pay the original cost of setting it.

The monthly allowance for any customer is obtained by dividing his monthly fixture rate by the regular meter rate per thousand gallons. If a customer should consume exactly his allowance each month, he would be obtaining water practically at meter rates, yet with the Water Company furnishing the meter, instead of the customer. The margin between what he does use and what he is allowed to use may be said to reimburse the Water Company for setting and maintaining the meter.

Before adopting a plan of this kind a water works company should carefully determine if its meter and fixture rates bear proper relations to one another. The rates should be such that the company would not suffer if fixture rates were abolished, and all customers paid by meter, taking into account the lesser amount of water required in such case. In this city we were influenced by the probability that we should be put to great expense increasing our water supply unless waste could be largely reduced.

We have had very little friction with our customers in carrying out this plan, as its fairness can be easily shown to almost any one. We have found a few customers who seemed to be legitimately using more than their allowance, while many others were not using one tenth of theirs, which goes to show how inequitable a fixture or flat rate system is.

Meters have been placed in school and city buildings and churches, all of which are supplied with water free, and especially in the school buildings have the meters paid for themselves many times over in restricting waste.

Whenever possible, meters are placed in cellars. In some cellars it has been found necessary to protect the meter from freezing. This has been done by building a rough wooden box around it, enclosing all the pipe back of the meter and inside the cellar wall, and as much of the pipe ahead of the meter as practicable. The top of the box is left open and it is filled with sawdust, which can be brushed away when the meter is read.

Even with such protection it is found that occasionally a meter will be frozen, on account of the water in the pipe outside of the box freezing, and the ice gradually extending back to the meter. The cost of labor and material for taking out, repairing, and resetting a meter averages about \$1.00.

In a building which has no cellar the meter is, if possible, set under the floor at the point where the service pipe enters the premises. A wooden box filled with sawdust as above described is usually required, and a trap door is made in the floor to provide access. It is seldom that a meter set in this manner freezes.

When yard hydrants or other outside fixtures are in use, or when for any other reason it is impossible to set the meter in either of the places mentioned above, it is set in a meter box out of doors. The box now used for this purpose is shown in Fig. 1, and was invented and patented recently by Mr. B. C. Palmer, street foreman for the Water Company, and the writer. It is made of iron, and is cast in two halves for convenience in molding. The halves are fastened together at diagonally opposite corners by bolts. The cover is held on by a bar attached to the pentagonal-headed bolt which passes through the cover. The bar engages two wedges inclined in opposite directions, so that

a quarter turn of the bolt will fasten or unfasten the cover. A second cover of wood rests on a flange cast on the inside of the box about twelve inches below the top. The air space between the two covers has never yet failed to keep the meter from freezing.

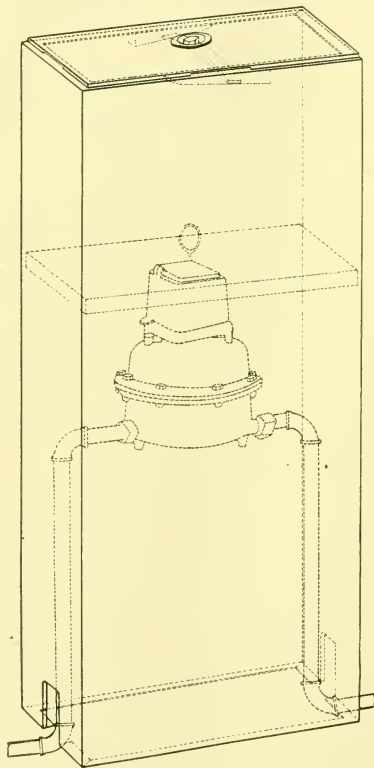


FIG. 1. — CAST-IRON METER BOX.

The meter inspector on his monthly rounds listens at every tap where it is possible to do so, and reports any case where there seems to be a leak back of the meter. To do this requires some time, but it is time well spent, as one or more leaks are found every month.

Since January, 1902, all taps have been laid with lead pipe by the Water Company's own men, including worn-out ones. Previous to that time galvanized iron (or steel) was used, and many of the older ones are giving out.

Nearly all the soil in this vicinity is impervious to water, and leaks are not long in showing at the surface, unless, as occasionally happens, they be close

to some drain which furnishes an outlet to the water. In considering the large amount of water pumped in 1900, it was thought that this might not be the case and that there might be

many leaks not appearing at the surface. Consequently it was decided to make a complete survey of the entire system to determine if this were true.

The apparatus used consisted of a horse and wagon, a 1½-inch Gem meter, 9 fifty-foot lengths of 2½-inch hose, gate keys, curb cock wrenches, and lanterns. The writer took personal charge of the work and was assisted by two men, one of whom was an old employee, familiar with the system. The work was done between the hours of 10 P.M. and 5 A.M., but in larger cities it would not be best to start so early.

After two or three nights it was found unnecessary to follow out in detail the original plan, but that certain modifications might be made which would greatly facilitate the work without making it any the less thorough. The original plan of operations will first be described, and afterward the ways in which it was modified.

Two gates were closed, thus cutting out the section to be tested. This section will be referred to as a "block," although in some of the older parts of the town, gates are as many as three or four blocks apart. A line of hose was laid from the nearest "live" fire hydrant to a "dead" one, and the meter placed in the line next to the "dead" hydrant. Both hydrants were then opened, and if the meter showed water to be passing into the "dead" block, its rate of flow was noted, and one of the men started to close the curb cocks in that section.

Careful watch was kept at the meter, and if after closing any curb cock the rate of flow diminished suddenly, or ceased entirely, it was concluded that either there was a leak on that service, or the customer was using water, and an investigation was made to determine which was the case. Whenever the flow ceased entirely, the investigation of that section was at an end. After closing all curb cocks, if water was still running through the meter, one or more leaks were shown to be in the "dead" block, and they were located in every case by listening at the curb cocks.

The work went on in this manner, block after block, for several nights, resulting in the finding of only two or three leaks. The writer then concluded to try four or five blocks at once. In this case quite a number of gates had to be closed, and most of

them were attended to in the daytime, leaving only as many to be closed in the night as were required for efficient fire service. At the first trial the meter stood still, so from that time on still larger sections of the town, containing from two to three miles of mains, were cut out and tested at once.

When a leak was found its rate of flow was noted, as before, and then the size of the "dead" section was reduced one block at a time by opening and closing the proper gates, working towards the meter. In this manner the block or blocks on which there were leaks were located.

After the first few nights the shutting off of curb cocks was discontinued, as very few leaks were being found, and those could be easily located, in the stillness of the night, by placing the ear against one end of the street key, holding the other end on the curb cock. In down-town sections of larger cities, however, where there is more or less noise from teams all night, it might be best to shut off the curb cocks.

When testing two or three miles of mains at once, a simple system of lantern signals was used between the man at the meter and the men who were opening and closing gates. Sometimes these latter were nearly a mile away from the meter, and without signals much time would have been consumed going back to it after cutting in each new block. The 1½-inch Gem meter was used, not because it is the best size or kind of meter for the purpose, but because it happened to be available. It has hose couplings, and is in regular use for measuring water taken from fire hydrants for miscellaneous purposes. Were the writer to do this work over again he would use a smaller meter of the piston or rotary type.

The method of finding leaks in street mains and services above described proved perfectly successful, as well as economical. It is thought that no leak escaped detection. The failure of a gate to close tightly was considered but the effect of such a case would have been only a somewhat reduced rate of flow through the hose and meter. Tests for unauthorized connections might be made in a similar manner in the daytime, first closing all known curb cocks. By taking one block at a time, patrons need be deprived of water for only a short period.

The effect of the above and other less important methods of discovering and restricting waste is shown by the following statement: The average number of taps in use in 1900 was 640, of which 32 per cent. were metered; in 1903, an average of 891 taps were in use, 72 per cent. of which were metered.

Average amount of water pumped daily per tap in 1900,	1 290 gals.
" " " " " " " " " " 1903,	648 "
	<hr/>
Difference	642 "
Decrease due to loss of five large customers	272 "
" " " restriction of waste	370 "
Estimated portion due to installation of meters, 0.8 of 370,	296 "
Total annual saving due to installation of meters,	
296 x 365 x 891	96 263 640 "

This may be regarded as a fairly close estimate of the amount of water which would have been pumped in 1903 in addition to what was actually pumped, had there been no meters placed on other than the usual proportion of new services, whose owners prefer to buy meters and pay meter rates. This saving has been brought about by the installation of 240 company meters, each meter thus being credited with 401 098 gallons.

In order to make sure that this amount is not overestimated, we will divide it by two, which gives, say, 200 000 gallons annual saving per meter. The cost of fuel and lubricating oil required for pumping 1 000 gallons is \$0.0094, or \$1.88 for 200 000 gallons. Deduct 17 cents, which is the annual cost of reading a meter, and 13 cents, the cost of maintenance, leaves \$1.58, which, at 6 per cent., represents the annual interest on \$26.33. This is a little less than double the cost of setting the average meter.

As stated above, enough meters have been set to increase the number of metered services from 32 to 72 per cent. of the total. It should be understood that meters have now been placed on all taps where there was especial likelihood that water was being wasted, such as saloons, livery stables, and stores, and that the remaining 28 per cent. represent mainly small customers having but one faucet or one yard hydrant. It will be seen that the meters which have been set by the Water Company have paid for themselves nearly twice over, in saving of fuel and lubricat-

ing oil alone. In addition, the expenditure of large sums for increasing the available water supply has been postponed at least five years, and probably more, as a direct result, not to mention lesser savings, such as wear and tear of machinery and boilers.

FIRE PROTECTION FOR FACTORIES: HOW ITS VALUE
SHALL BE DETERMINED AND WHO
SHALL PAY FOR IT.

BY J. H. PURDY, PITTSBURGH, PA.

[*Read February 10, 1904.*]

When the Secretary asked me to say something upon this subject, I thought I was going to be able to hunt up some data that would have a fixed value for the Association. Unfortunately, I was called away from home and didn't get back until Monday of this week, and when I began to look up authorities from which I could make an article, I was astounded at the absolute lack of authorities upon this subject. However, I prepared a little paper here that raises some questions and gives some ideas of the questions.

"Fire protection for factories: how its value should be determined, and who should pay for it." The rapid stride and growth of our towns and cities have brought us many problems. The development of the small mill or shop to the great factory building, or group of buildings, filled with costly machinery and raw and finished materials, has forced the question of how best to protect such buildings and their contents from fire upon the careful attention of not only the owners of such properties, but also of insurance companies, municipalities, and water companies, and by first glancing at the interests of each in the protection of such properties, it will no doubt assist us in forming some conclusions as to kinds of protection or part the water departments or water companies should take in furnishing special facilities for fighting fires on such premises. In most cases the city authorities are liberal in placing fire hydrants in near and handy locations to large factories, if the water works are owned by the city; if by a company, the city usually orders hydrants placed by the company handy to such buildings; if it is a town of some size, chemical

engines, steamers or hose carts, with all modern appliances, are provided by the city or town authorities and kept conveniently near for ready use. In addition to this, the proprietor usually has grenades, or small fire extinguishers, placed at convenient places throughout the premises.

All of the devices and means mentioned are generally provided and maintained by the municipal authorities and the mill proprietors, and are only mentioned to show the joint interest of the authorities and the owners, and to distinguish them from the special means of protection to which our subject refers. Under this heading of special protection, we may divide it into three classes:

First. Fire hydrants on the premises, usually having threads or nozzles interchangeable with the hose of the city fire department.

Second. Standpipes in the building with hose attachments at convenient places on each floor, having hose attached at all times ready for instant use; in many cases with valves which open automatically as the hose is unrolled and brought into action. Water departments and water companies usually insist that the pipe lines leading from their mains to such inside fire hydrants or standpipe lines shall not be tapped or used for any other supply. Insurance companies have objected all along to the placing of meters upon any such supply or any restrictions that would in any way interfere, as they thought, with the free use of such lines. There will be made to-morrow, in Burlington, Vt., some tests of meters upon such fire supplies by the New England Fire Association. To that test invitations were issued to the General Committees of the American Water Works Association, and I was appointed upon a committee at the American Association last year on insurance, involving some of these questions. But I only digress to show this question of special fire protection is a new one and coming into prominence in every manufacturing district, forced upon us by the insurance companies.

Third. The sprinkler system has come into extensive use in the last few years as one of the most effective means of preventing disastrous fires in factories and stables by putting out the small blaze and stopping the fire at the start. It consists of a network

of pipes, usually hung to the ceiling of the different rooms or departments. Such pipes are generally run along over the shafting and over points in the rooms where there is thought to be the greatest danger of fire starting. Attached to these pipes at every point where there is danger of fire are sprinkler heads screwed into the pipe. Parts of the sprinkler heads are made of soft metal strong enough to withstand the ordinary pressure on the water pipes but soft enough to melt from the heat of a fire occurring near them, and they are so constructed that when the part melts the water under pressure is sprinkled upon everything in its immediate vicinity. As the sprinkler pipes are kept constantly full of water under pressure, the opening of these heads letting out the water directly over the fire at its start usually prevents its spreading. The usual method of connecting is to have pressure on the sprinkler system maintained from an elevated tank, but in addition there is always a direct connection from the street mains. The tank is used because there is no fluctuation of pressure, the soft sprinkler head being weak and liable to break and leak under a variable pressure. It is thus seen that all of these plans for putting out fires, either small or large, rely upon the water department or water company for a certain and ample supply of water, always ready and in sufficient volume and pressure to meet the maximum demand of those who rely upon any or all of the means described.

To meet this requirement the water departments or companies have been compelled to plan and build on a much larger scale than they would if the only demands upon them were to furnish water for domestic uses or the supply of boilers, etc. Supply lines and street mains, pumps, boilers, and reservoirs must all be planned on such a scale as will meet the requirements of fire hydrants and sprinklers in addition to the domestic and manufacturing demands.

How shall the value of this special service be determined? Plainly, metering the water going through these special lines would not compensate the water department or water company for their extra investment in the larger reservoirs, pipes, pumps, and water supply needed, as the hydrants, standpipes, or sprinklers may be in position for years without being called into use, so that

the only just and fair way is to fix a charge based on the size and capacity of the fixtures erected and the amount of water which you have placed at the disposal of the party owning the premises and erecting the hydrants, standpipes, or sprinklers. In some places a charge is made per year for each sprinkler head. At others an attempt has been made to arrive at a rate based on the area of floor or space protected. Another method has been to base the charge on the size of the pipe connection to the water company's mains, but all of these are only means of fixing the amount or volume of service rendered, and the value of it must be determined by agreement between the parties.

Insurance companies will name a certain premium where sprinklers are used and a higher rate where they are not. The difference between these amounts is the money value per year the insurance companies place on these special facilities. If we can now get the value of the plant or goods protected or the amount of insurance carried, we can readily calculate the annual cash saving, from which must be deducted interest on the cost of installing the sprinkler system, and I think an equal division of the remainder between the owner and the water company would be fair value for the service, and would certainly be fair to the owner, as he gets one half of the insurance saving and has the added security against interruption of business and damages not covered by insurance. Charges for standpipe and hydrants are usually the same as the city or town pays per year for its fire hydrants. Where the plant is owned by the city, I cannot find that there is any custom.

The argument is frequently made that these appliances are so rarely used, and so little water during the year is required of them, that no charge should be made for them beyond the value per thousand gallons of water used. This is as surely wrong as to say if you chartered a railroad train for a year and held it under steam for your use the entire time but only found it necessary to make one journey, that you should only pay ticket fare for the one trip. Now who should pay for the special service? The community is surely interested in protecting the property of the factory or business which has done so much for the prosperity of the town, but has it not discharged its obligation when it gives

to it the same measure of protection which it gives the smaller business store or shop, or the residence, barn, or office of any other citizen? Insurance companies are, of course, interested parties, but as their premiums are reduced in proportion as these special means of protection are provided, or are increased if they are lacking, and as the reduction in premium remains in the owner's pocket, in whose name and for whose benefit the policy is written, it seems to me that payment for the use of the water department's or water company's facilities to the extent and in the manner described should be made in every case by the property protected just as much as they should pay for the small tap or supply for ordinary uses. In these special protection cases the department or company places, subject to the emergency needs of the owner of the factory, pipe connections so large as to form a large percentage of the pump, reservoir, or supply main capacity. Bear in mind also that pump, reservoir, and supply main have been built and must be maintained and enlarged on a much more liberal scale than would be required if it were not for this special service, and there is no question, in my mind, that the property owner should pay for the special service.

REPORT OF COMMITTEE ON PRIVATE FIRE
PROTECTION.

[Presented February 10, 1904.]

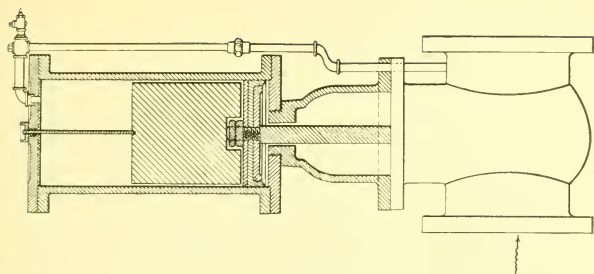
Since our report, made at the Montreal meeting, Mr. Tilden, of the Hersey Manufacturing Company, has submitted to your Fire Pipe Committee a device designed to overcome the most unsatisfactory feature of the control of large services, at that time pointed out, viz., The inability to accurately measure for any considerable length of time the smaller flows, leaks and waste.

Mr. Tilden's device for accurately measuring small streams and delivering, either with or without registration, larger streams without objectionable frictional loss, consists of a meter, — in the device submitted a 3-inch meter, — set in a by-pass around a double faced gate valve with parallel seats, the face toward the pressure being bored to admit of the passage of water through the same, and thence up around the stem into a cylindrical chamber directly above the valve, through the center of which the valve stem extends (see Fig. 1).

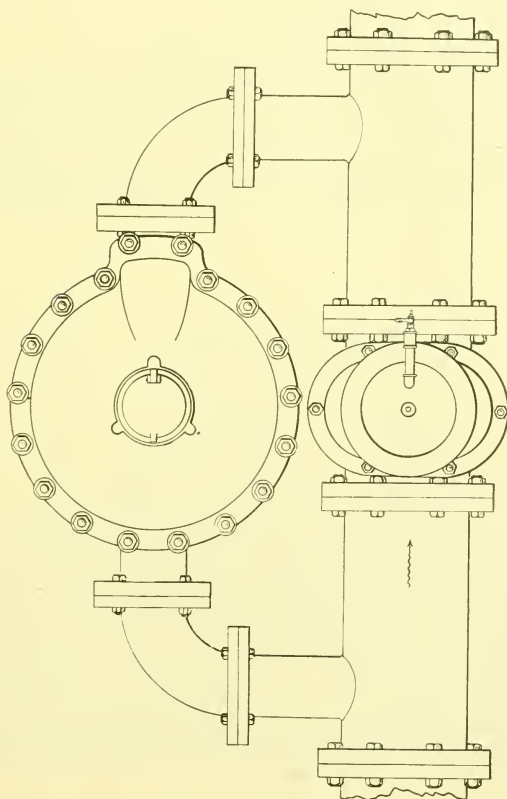
In the cylindrical chamber, attached to the valve stem, is a cup-leather plunger, placed cup down, or against the pressure, and weighted to such extent as with the weight of the valve and stem to constitute a force tending to keep the valve closed, equal to the pressure per square inch which it is designed to absorb in the apparatus.

The stem above the weighted valve extends as a light rod, or pin, through a stuffing-box at the top of cylinder, and by its position, either just protruding through the stuffing-box or extending above the stuffing-box, a distance equal to the motion of the valve or less, indicates its position.

The cup-leather packed valve-operating plunger is, as regards the pressure from the lower or inlet side, absolutely tight. The valve itself is, as used, a single faced gate, closed by the pressure.



SECTIONAL ELEVATION.



PLAN.

FIG. 1. — Tilden Device for accurately measuring small flows, and permitting the passage of larger flows without registration and with but slight frictional loss.

The pressure at the inlet, conveyed through the hole in the valve, and up around the stem to the under side of the valve-opening plunger, is balanced by the pressure on the outlet side of the valve, the same being conveyed to the top of the plunger through a brass tube (shown in Fig. 2, Plate I, and Fig. 1, Plate II).

Under static conditions, inlet and outlet pressures being equal, the valve is held down by the weight of its parts, and on experiment was found to be tight, and to remain so until, by reason of the inability of the metered by-pass to deliver water as fast as required, the pressure on the outlet side dropped to about 5 pounds below that on the inlet side of the device. At this point the discharge was about 175 gallons per minute.

As the demand for water, for fire or other purposes, increases, and the outlet pressure diminishes, the difference of pressure on the two sides of the valve-operating plunger causes the same to rise, maintaining until the valve is wide open, a difference in pressure between the inlet and outlet not in excess of that for which the device is designed, — in case of the device tested, about 8 pounds.

Tests were made under varying rates of flow, from 1.2 gallons per minute, to about 2 600 gallons per minute, all of which tended to substantiate the claim of the inventor, that the device could be relied upon to accurately measure streams up to its designed capacity, and to deliver, without excessive frictional loss in the device, larger streams, up to the capacity of the supply.

For the purpose of securing information in regard to the opening of the automatic gate, a wax seal is placed over the pin extension of the valve stem, which, on the opening of the valve, is broken by the rising pin.

A stop in the brass tube through which the outlet pressure is conveyed to the upper side of the operating plunger, and a pet-cock on the top of the cylinder, by the opening of which the upper or outlet side of the plunger may be exposed to atmospheric pressure, together enable the manual operation of the valve for purposes of inspection and test, or for the purpose of removing the resistance normally imposed by the device (see Fig. 1, Plate II).

There being practically no flow through this brass tube, its function being simply to transmit pressure, and it being of non-

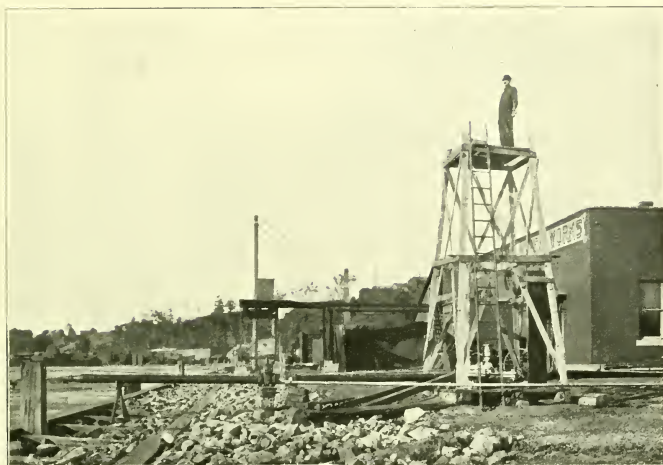


FIG. 1.—General view of testing apparatus for large streams, showing discharge into Lake Champlain on the left and pumping station buildings on the right.

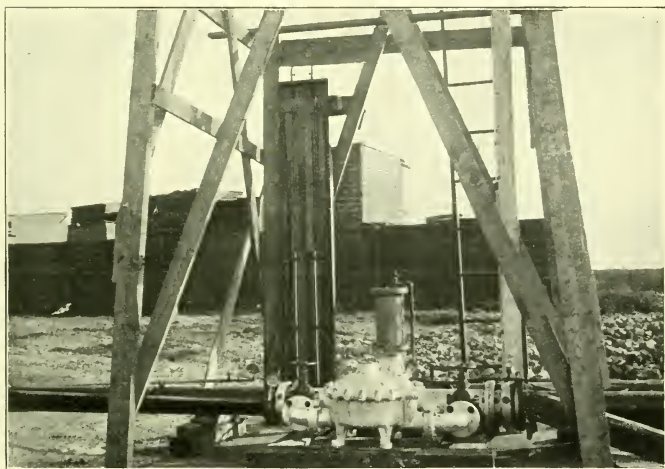


FIG. 2.—Tilden Device in testing apparatus at Burlington, showing metered by-pass around automatically opening gate between piezometer rings in foreground. In the background, on the left, U mercury gage for determining frictional loss in the device; on the right mercury nozzle gage for determining nozzle pressure.

corrosive metal, there is no chance for accumulation or clogging of the tube, and no advantage to be derived from an increase of its diameter. While lengthening the tube to the vicinity of a probable point of discharge would result in a wider opening for a given discharge, the gain would be slight, and more than offset by loss of compactness.

The sticking of this valve by an excessive back pressure is a very remote, not to say impossible, contingency. First, because of the equalizing effect of the metered by-pass. Second, because the capacity of the brass tube, conveying water to the outlet side of the operating cylinder, is not sufficiently in excess of the possible leakage past the reversed cup-valve to admit of the accumulation of excessive pressure on the outlet side, even were the metered by-pass absolutely tight shut. Third, because the wedge, separating the valve discs as they reach their seats, is too flat to admit of sticking. Fourth, because of the presence, in the service, of a swing check to prevent the flow of water to the main.

The sticking of the valve from lack of operation is equally improbable, for where such a device is in use, it should be inspected and operated monthly by the Water Department.

The underwriters' inspector, knowing such a device to be installed upon a risk, and failing, on his inspection, to see it operated would be guilty of gross negligence, and that, in an underwriters' inspector, would be simply inconceivable, and furthermore, the private fire services, on which such a device would not be opened several times a year for flushing sewers, watering grounds, or other cause, are extremely rare.

A back pressure of about one hundred and ten pounds, measured at the outlet piezometer ring, was repeatedly applied to the device examined for the purpose of developing a stick, which it utterly failed to do.

The best feature of this device is its adaptability to a wide range of conditions and requirements. By varying the length of the operating cylinder, and the weight of lead used therein, the amount of frictional loss required to open the valve may be made to conform to that to be spared under the particular conditions encountered.

By varying the size of the metered by-pass, the sensitiveness and range of the device, for the measurement of small flows, may be regulated to meet different requirements in that respect, from the opening of the automatic gate on a 5-pound frictional loss, caused by a discharge of about 70 gallons per minute through a 2-inch meter, or 175 gallons through a 3-inch meter, to the opening on the same frictional loss by a discharge of about 400 gallons per minute through a 6-inch meter.

A meter, full size of the service, in the main line with the automatic valve, around both of which a by-pass with a meter capable of detecting small flows, leaks and waste, is taken, will enable the registration, with approximate accuracy, of all water used, both large and small streams.

Your Committee, having carefully examined and tested the device submitted by Mr. Tilden, are satisfied that it will afford, in many cases, a satisfactory means of determining the amount of water passing through services supposed to be used for fire purposes only.

The performance of the valve under test was most satisfactory, the frictional loss being much less than might reasonably have been permitted. The device is of the simplest character, the only part subject to clogging being the meter, the clogging of which serves only to cause the automatic gate to open under a less discharge than it should. Experience seems to have demonstrated that the principle of the device, which is by no means new or untried, is excellent, and that the failure of a properly installed apparatus to perform its designed work is next to impossible.

Reaffirming the statements made in their report at the Montreal meeting, your Committee would respectfully submit their further findings, in regard to the control of large services, as follows:

In cases where a failure to register the smaller streams is deemed of little importance, a meter as sensitive as the Crown, Hersey Disc, or Empire, as tested at Knoxville, or, in case it be deemed advisable, such a meter in a by-pass around a gate, to be kept closed except in case of fire, will accomplish the desired result. Unless the failure to register the smaller streams be deemed of little importance, no large meter will, for long, be sufficiently

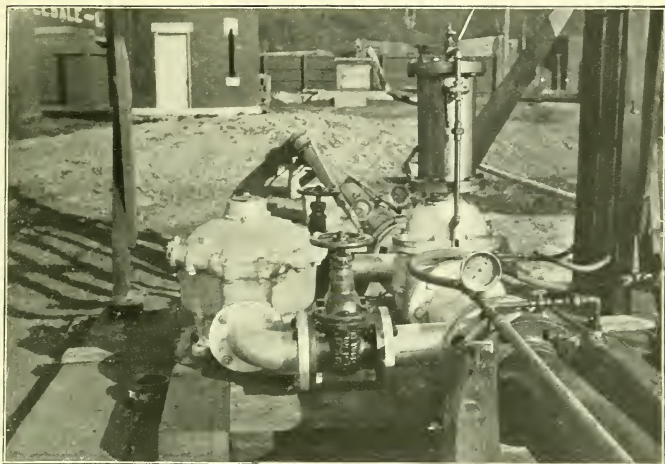


FIG. 1.—Tilden Device in testing apparatus at Burlington, as seen from outlet, showing brass tube for transmitting outlet pressure to cylinder with stop and pet-cock to enable manual operation. Metered by-pass on the left, automatically opening gate on the right. Six-inch supply line and tank for weighing discharge of small streams in the background.

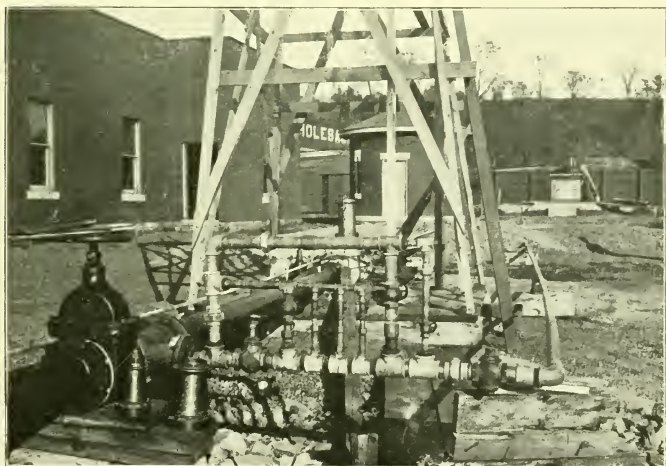


FIG. 2.—Tilden Device in testing apparatus at Burlington, showing in the foreground gridiron through which two-inch and smaller streams were drawn into tank on scales, seen in background; also six-inch gate through which streams were thrown through calibrated nozzles into the lake.

PRIVATE FIRE SERVICES.

At the last annual convention of the New England Water Works Association, the following motion, made by Mr. Frank C. Kimball, Superintendent of Water Works at Knoxville, Tenn., was unanimously passed:

“That a committee of three be appointed by the President, whose duty it shall be to ask for the appointment of and to confer with similar committees from the American Water Works and other kindred associations, and also with the various underwriters' associations, to agree, if possible, upon some adequate means of controlling private fire supplies acceptable to all parties concerned, including therein all questions relating to charges therefor and similar matters.”

Messrs. F. H. Crandall, of Burlington, Vt., R. J. Thomas, of Lowell, Mass., and Elbert Wheeler, of Boston, Mass., — the committee appointed in compliance with the instructions contained in the above motion, — would respectfully invite correspondence and suggestions from all interested in a fair and equitable assessment of the benefit conferred in supplying fire protection by means of private fire protective systems.

The committee, so far as their investigation has progressed, find that nearly everywhere, both in case of public and private ownership, it is customary to recognize the service of the water works to the public, in the line of fire protection, a frontage tax, hydrant rental, general appropriation, or an overdraft, serving as means to secure the assessment upon the property benefited, of the cost of fire protection.

The capacity of works necessary to supply the volume of water required to make private fire services of value, the leaks habitually permitted on unmetered services, to which fire services are no exception, and the stealing which not infrequently takes place from such services, all entail expense, to cover which an assessment should be made upon the parties directly benefited.

As in the case of schedule rate assessment, the convenience or advantage accruing from additional fixtures, together with the

additional cost of the service, constitutes a basis for increased assessment, so in the case of fire protection, increased benefit and increased cost of service constitute a basis for increased assessment.

The individual benefit enjoyed by the possessors of private fire protective systems is far in excess of that enjoyed by the general public, to which latter benefit, by reason of payment of taxes, all are, to a reasonable extent, entitled.

As Hon. J. O. Hall, of Quincy, said at the 1902 Convention of the New England Water Works Association: "The individual taxpayer should not be compelled to bear any burden which, by any interpretation, can pass into an individual benefit to somebody else."

That private fire protection should yield the company, or department, furnishing it, a fair return; that a request for a service for fire or any other purpose, unaccompanied by willingness to furnish correct and trustworthy information as to the amount of water used or wasted through it, is unreasonable, and that the size of services, for whatever purpose used, should be kept well within the capacity of the system to supply, without excessive loss of pressure, are conclusions easily and speedily reached. How to determine an amount constituting a fair return is a question upon which the committee find room for a greater difference of opinion.

The committee promise, to all communications and suggestions, their thoughtful consideration.

F. H. CRANDALL,

R. J. THOMAS,

ELBERT WHEELER,

Fire Pipe Committee, N. E. W. W. A.

sensitive to meet reasonable requirements as regards the detection of small waste.

In cases where a failure to register the larger streams is deemed of little importance, a device, like that submitted to the Committee by Mr. Tilden, the metered by-pass being made larger or smaller as the circumstances of each individual case may require, will accomplish the desired result.

Wherever a device permitting the passage of the larger streams without registration is permitted, it should be clearly understood and agreed that in case of opening the automatic gate for any other than fire purposes, the amount estimated to have passed unregistered should be paid for, and that should its frequency of opening demonstrate the use of the service to be in excess of the capacity of the device to accurately measure, a device or meter capable of correct registration should be at once installed at the expense of the user.

In cases where the measurement, with approximate accuracy, of the entire supply is desired, a device like that of Mr. Tilden, with a meter of the full size of the service in the main line with the automatic gate, around both of which a by-pass with a meter capable of detecting the smaller streams, leaks and waste, is taken will accomplish the desired result.

While not wishing to be understood as taking the ground that no better means than those above suggested for obtaining the desired results can be devised, we are satisfied that they are the best at hand, and are amply sufficient.

Respectfully submitted,

F. H. CRANDALL,

R. J. THOMAS,

ELBERT WHEELER,

Committee on Private Fire Protection.

DISCUSSION.

MR. FRANK L. FULLER. I should like to ask Mr. Crandall how his determinations of the loss of pressure agreed with either the Ellis or the Weston tables.

MR. CRANDALL. I have not done the work in comparison which I expect to do. It was rather late in the season, and the deter-

mination of the loss in the pipe was a sort of after-thought and not immediately connected with the work in hand, so that before saying anything about it I should like to repeat the experiments and get intermediate data.

MR. FULLER. It seems as though it was a very good opportunity to get accurate results.

MR. CRANDALL. We did get some results, but I should prefer to look the matter over more carefully, duplicate and add information before saying anything with regard to the differences between the results of these experiments and the tabulated statements that we have.

MR. AUGUST FELS. I should like to state that the Lowell Water Board has bought a device like that which Mr. Crandall has explained, and what he has shown in the pictures you can see in actual operation at Lowell. If it is in order I would move that the committee be continued.

MR. THEODORE H. MCKENZIE. Do I understand that Mr. Crandall recommends that a proper rate for fire protection is one-half of the difference in the premiums paid to the fire insurance companies, — that is, the difference between what was paid without protection and what is paid with the protection?

MR. CRANDALL. That was Mr. Purdy's suggestion in his paper which I read.

MR. MCKENZIE. I supposed the committee was to make some recommendation so that water works superintendents could have some basis for a charge for fire protection. It is one of the most difficult problems that we have to encounter, the matter of establishing rates for sprinklers and hydrants and standpipes.

MR. GORHAM DANA. Mr. President, I represent the Underwriters Bureau of New England. Unfortunately I am the only insurance representative here to-day. I wish I was not, for I think there is a great deal to be said on our side. I had the pleasure of attending the tests at Burlington which Mr. Crandall has been describing, and I feel very confident in saying that the Tilden automatic valve will not be acceptable to the insurance interests. Any valve of that kind requiring a packed stem and complicated moving parts and a small pipe to convey the pressure, is a complication which we have been trying for years to avoid in

fire protection work. At present we have a dry valve which we have to contend with occasionally. They have been made as simple as possible, but they are still so complicated that we do not always grant the same rate of insurance where they are used as we do on a straight wet pipe system. Now the Tilden valve is more much complicated than any dry valve; or, I should not say more complicated, but there is more chance of obstruction in the Tilden valve than in any dry valve I ever saw, and I think the principle is wrong. I do not think we want to rely for fire protection on any valve which has a moving packed piston which is liable to get stuck and clogged by sediment, and also a small pipe transmitting pressure which is liable to get clogged and in which there is a valve which is liable to be left closed.

While in the tests at Burlington the valve worked satisfactorily, that was no test of the effect of wear and age. The only way to test such a valve is to have one in use for years under unfavorable conditions and then see what the result is; and I feel sure that in some plants that I know of such a valve would get very badly clogged with sediment. We have had cases where $\frac{3}{4}$ -inch sprinkler pipes have become entirely clogged so we couldn't get a drop of water through them. Those were pipes where there was hardly any flow and much less chance for sediment than in pipes where there is a flow.

In regard to inspecting these valves, it has been said that they should be tested once a month, but I don't know of any place where the insurance companies can afford to make such frequent inspections. The average is perhaps once in six months, and the chances are that such a device would be put in places outside of New England where inspections are not so frequent as that. The thing might go a year easily without insurance inspection, and I think in such a case as that there would be a very good chance of having trouble. So far as the insurance companies are concerned I wish to say that we do not wish to accept this device without a long-continued series of tests.

MR. ROBERT J. THOMAS. I was present at this test in Burlington and saw the operation of the Tilden valve there for the first time, and it impressed me very favorably. Since then two of them have been purchased or ordered for trial in Lowell, and one

is now in use in our shop on a fire service. I have watched it very closely, and I cannot conceive that there is the remotest possibility of the valve sticking. I think the insurance companies in objecting to this device are either not sincere, or else they are not fully informed as to the operation of the same. Take for example the remark of the gentleman who has just spoken as to the clogging of the small pipe which conveys the pressure to the top of the valve; the effect of the clogging of that pipe would be that the valve would open and remain open; consequently it would not affect the insurance people a particle, for it would give them the full 6-inch pipe.

Now, I take it for granted that most water works men are willing that the water used for the extinguishment of fires should be furnished gratis, but they believe that the corporation or manufacturer who uses water through a fire service for any other purpose than for the extinguishment of fires should pay for it, like the humblest water-taker in the city, and that he should not have any extra privileges above the average citizen. Now, how can this be done without putting on a meter? The water works superintendent must put a meter on to arrive at the amount of water used or wasted. He should at the same time put on a device that in case of fire will give the fullest possible amount of water for the extinguishment of the fire, and where sprinklers are open will supply them all the water that the system can furnish and with the least loss of head or pressure. That is the idea of the water works man. If you put a positive meter on you will get a registration which is fairly close, but where you are drawing a large quantity of water you are going to reduce the pressure so you possibly will not have in the top of a high building pressure enough to operate your sprinklers effectively. With the Tilden device, or any device similar to this, all you have to interfere with the delivery of the water is simply the friction in the pipe. What better service can you have? If you use a current meter which will not obstruct the flow of the water as much as a positive meter, then you will not have registration of the fine streams. Then again comes the question whether or not it is important to the water works to have the small flows measured, — whether there is sufficient waste of water through leaky joints

in pipes and in other small ways which a current meter would not record.

I recently received a letter from the people whom the gentleman who has just spoken represents, proposing a system of inspection by the insurance inspectors, whereby they would report to the water works office any infraction of their rule which prohibits connection with sprinkler pipes for any other purpose than for fire protection. But we have in Lowell, — and I presume it is so in almost every manufacturing city in New England, — a number of fire services which are laid in the ground for a long distance, and some of these pipes have been laid for over thirty years. In the mill yards there are race-ways and underground water-ways of various kinds that these fire pipes cross. Now how is the insurance inspector going to tell us whether there is a leak in a pipe under a brook or river or race-way? There may have been leaks in pipes laid in this manner for years and we may have been losing water all the time, and if we were brought up before a committee of the city government and asked how we know about the consumption of water in this or that large concern, whether we were getting paid for the water used or whether we knew how much water was used, we would have to admit that we didn't know anything about it. But if we put a meter on the fire service we do know what is going on, and if we give them a meter which will furnish an efficient fire service, a bountiful supply of water, with sufficient pressure for their sprinklers and their fire pipes, making them pay for what they use for other purposes, I think we are using them right, and we certainly then can stand up before the public, the other water-takers, and say that we are using the large consumers just the same as we are using the small ones. That is what we are trying to get at, and, as I said in the beginning, I think the more the insurance companies study this device of Mr. Tilden the sooner they will come to the conclusion that a device like that is a good deal better for them than a positive meter; and if they are not willing to accept it, I apprehend that the water works people will enforce the use of positive meters on the fire services. The result will be that where one fire service will give them sufficient water without a meter, when a meter is placed, it will be necessary for

them to have two fire services instead of one and consequently two meters.

I think I am voicing the sentiment of the committee when I say that, so far as they have examined this device of Mr. Tilden's, and so far as they can understand the mechanical operation of it, they totally disagree with the insurance people in considering it possible, not to say probable, that the valve may stick. Why, the valve manufacturers have been making a valve similar to this for seven or eight years and possibly longer, which they call an automatic hydraulic valve. You can see a description of it in their catalogues. It is possible that several towns and villages where there are large manufacturing establishments are at present supplied through automatic valves of this same kind, probably not so good, because in the automatic valve known as the hydraulic valve there is a stuffing-box and the stem is packed. In this device of Mr. Tilden's there is no packing around the stem. The stuffing-box is taken out and the water passes up by the stem, making it less liable to stick than the ordinary hydraulic valve, which has been in use for years. Mr. Crandall has told you about the device which has been in operation in Burlington for seven or eight years, and he has never had any trouble with it. It has a cup-valve on it, similar to the cup-valve on the Tilden device, and he has never had occasion to replace that valve; it has never given them any trouble. I say again that in my judgment the insurance people are not reasonable in their opposition to this device of Mr. Tilden's.

MR. DANA. Mr. President, in reply to the gentleman who has just spoken, I would like to say, first, that if the small pipe which conveys the pressure to the upper side of the piston is clogged, it will prevent that valve from opening, provided the valve is closed when the clogging takes place, because in order to open the valve the pressure must be released above it, and if that pipe is clogged or allows the pressure to go in and out from above that it will necessarily keep it closed.

In regard to the necessity for such devices, that is a question which I did not start to argue, and I think it has been argued very thoroughly in this Association before from what I have been told, although I have never heard it argued myself. I think, however,

there is one point which should be borne in mind, and that is that there are different kinds of plants, some that need meters, perhaps, and some that do not. A large majority of the factories that are equipped with sprinklers have no outside piping at all. They are in cities, they take directly from the street main which is not more than 15 or 20 feet from their building, and there is absolutely no chance to tap the pipe between the street main and the building. Inside the building there is a chance, but that is looked after carefully by the insurance inspectors. And most modern plants have an alarm valve that absolutely prevents the flowage of water through the sprinkler pipes without giving an alarm, and it isn't likely that people are going to have the alarm ringing all the time in order to steal a little water. In large plants, where there is a great deal of yard piping, a meter can be placed in the yard, where the pipe enters the yard, with a by-pass which can be opened from a distance in case of fire, and that would be a comparatively safe arrangement. But the idea of making everybody pay for the faults of a few is not in my estimation correct.

MR. E. W. KENT. I have had some little experience with manufacturers who have been negligent in the care of their plants and have allowed a large waste to extend over a period of twenty-four hours. During the past month I lost 691 000 gallons of water in one plant in twenty-four hours. A line of sprinklers had frozen, some eight heads had burst, and one line of 2-inch pipe under 120 pounds pressure had blown off, so that the discharge through a 2-inch orifice continued for twenty-four hours unchecked.

PRES. E. C. BROOKS. I may say that I was rather glad to hear the gentleman who represents the insurance people say that they had found sprinkler pipes clogged. It has been a wonder to me that the insurance people put in, or allowed to be put in, plain black pipe for fire protection. We all know that plain black pipe fills up very rapidly, and it seems to me that the slight difference in cost between that and galvanized ought to be no bar to the introduction of galvanized pipe for purposes of this kind, where they are really desirous of keeping the pipe free from corrosion. And as to the Tilden device, I don't believe that there would be any difficulty about making every part of it of composition, so

that as far as corrosion is concerned it should be perfectly free from that troublesome feature. It seems as though the objection on that ground was something which is merely a matter of detail which can easily be gotten over. I should be very much pleased to hear from some of the other gentlemen as to their experiences.

MR. DANA. When I spoke of sprinkler pipes clogging I did not refer to corrosion but to sediment in the pipes. Our experience has been that in sprinkler pipes, where there is no flow, there is very little corrosion on the inside. The trouble we have is from sediment which comes from the water. I have seen pipes which have been installed fifteen or twenty years taken down, and they were almost as clean inside as when they were put up, so far as corrosion was concerned. It is the sediment which causes trouble. And the same might be said in regard to the Tilden valve; I don't so much fear corrosion as I do sediment.

MR. THEODORE H. MCKENZIE. Mr. President, I cannot quite understand how the sediment gets into this pipe when there is no circulation, no water flowing through it.

MR. DANA. In the case I referred to there was a test-pipe at the top of the building which allowed the insurance inspectors to test the system to see if there was water in it. That caused a slight flow about twice a year, and that was what did it.

MR. FREDERICK N. CONNET. In very many of the large mills there is an underwriters' pump, and the pressure that can be obtained by that pump is generally in excess of the city water pressure. The water department, fearing that the impure water pumped by that pump may enter the mains, requires a check-valve between the main and the mill. Now a check-valve being there is not objected to by the insurance companies, and if that check-valve is loaded with a weight and is used in the place of Mr. Tilden's device, you can prevent the water flowing through it, unless the pressure on the two sides of it differs by more than 3 or 4 or 5 pounds or any determined amount. If you place a meter in a by-pass around that check-valve you get very nearly the same conditions that you get with Mr. Tilden's device, and I don't see why that is objectionable, unless there is a chance for the check-valve not to be perfectly seated, and therefore a certain amount of water might get through the check-valve without being

measured. It seems to me that the simplicity of this arrangement commends it.

PRESIDENT BROOKS. I think that everyone who has had much to do with check-valves has regretted very often that they are not more perfect than they are. If there is anything in this world which will give trouble when you do not expect it, it is a check-valve.

MR. CONNET. But, Mr. President, isn't the only trouble which has been found with check-valves due to their not closing?

THE PRESIDENT. Yes, sir.

MR. CONNET. They will open under all conditions, but they may not close, and therefore I do not see why the insurance companies should object to them.

MR. F. H. CRANDALL. As I understand it, Mr. President, what we are looking for is not something which will satisfy the insurance people, but something which will enable us to know how much water is used or wasted on the premises which are supplied through these fire pipes; and the fact that a device will permit, or may be expected to permit, very small streams to pass through it without registration or without warning is sufficient to condemn it. If we were studying to get up something to satisfy the insurance people we would not have to do anything at all, because they are satisfied where there is nothing. It is a fact that the water departments and the communities generally are becoming dissatisfied with the abuse of privileges which have been granted, or with the neglect to properly care for favors that have been conceded, and that is what has brought about this investigation and discussion. The check-valve has been thoroughly tried and found wanting.

Twenty-three years ago good mechanical engineers saw in "the packed stems and complicated moving parts" of the Burlington motor insurmountable obstacles to its safe and satisfactory operation.

Experience with the motor has entirely done away with the misgivings inspired by its formidable appearance, as it will, I have no doubt, with this device.

The meter on such a device would naturally be inspected as often as the other meters on the system, and a department finding

it worth while to install such a device would naturally deem it even more worth while to be assured not only of its correct registration, but also of its preparedness for satisfactory operation under all conditions.

MR. DANA. Mr. President, if this Association cares to go ahead without consulting the interests of the insurance people, it seems to me it would be unwise, for they certainly have rights; and if devices are put in which the insurance people find by tests to be unsatisfactory, their only redress is to raise the rate up to what they consider it is worth, and that I think they will do. They certainly cannot take chances with imperfect devices, and they are surely not making enough money nowadays so they can afford to take unnecessary chances.

MR. LEONARD METCALF. I have listened to Mr. Crandall's description of this device and to this discussion with a great deal of interest. Unfortunately I have not yet had an opportunity to see the device in action. One thing occurs to me, which has been suggested by the discussion, that I might allude to. We all recognize, of course, that there is a great difference in the character of the water which is supplied by different works in different parts of this country. I think it may be said, generally speaking, that the water which we are accustomed to use in this part of the country, in the Northeast, carries fewer solids, — much less sediment, — than the water which we find in many works in the Middle West and in the South, so that we would look for a great deal more trouble from sediment in those regions than we would in this vicinity. It occurred to me as Mr. Dana spoke that the difficulty of the closing up of this small pipe leading to the cylinder could be met either by making that pipe large enough to meet their requirements, or by not only making it larger but also by making it possible for the insurance inspectors to test that pipe by permitting water to flow through it at such times as they visit the mills.

In regard to the cylinder itself, I can conceive of conditions under which I should think it might clog with sediment in the water. However, if the leather cup clogs seriously, I should think that a metal piston might be used, which would be less likely to clog. Large particles, of course, can be screened out by

simple screens. Smaller particles might with a leaky piston be gradually screened out by the piston and allowed to plug, and under those conditions I assume that the piston would not work. But with our waters in the North I should think the chances of that would be very much smaller than in the South and Middle West.

MR. ROBERT J. THOMAS. I will state that on this pipe which leads to the top of the valve there is an arrangement by which the pipe can be opened at will by anybody. There is a valve on it, or plug-cock, by turning which it can be demonstrated at once whether the valve or pipe is clogged or not. That could be easily done by the meter inspector every time he goes there to read the meter.

THAWING FROZEN SERVICE PIPES BY ELECTRICITY.

BY FRANK A. MCINNES, ASSISTANT ENGINEER, CITY ENGINEER'S
OFFICE, BOSTON, MASS.

[An Informal Talk at the Meeting of March 9, 1904.]

Mr. President, — My experience with electric thawing has not been very extended. The method is not new, as it has been tried in the West to a considerable extent. About three weeks ago a friend from Missoula, Mont., told me they were thawing pipes out there by electricity, and I thought it was time for the city of Boston to at least try the experiment. The water commissioner was kind enough to say "Go ahead," so I at once got Mr. Eldon, electrical engineer of the Edison Company, interested, and we went to work.

We have thawed about 20 services; the shortest time taken was three minutes, and the longest about eight minutes, depending upon the strength of the current. We first used the Edison alternating current of 2 250 volts, with a 30 kilowatt transformer and a water rheostat inserted in the primary circuit; the resulting current was approximately 280 amperes at 58 volts. In the secondary circuit an ammeter was used to determine the amperes flowing and a voltmeter to determine the pressure. One of the secondary wires was connected directly to the service pipe inside of the house, the other to a hydrant on the main pipe in the street; in about four minutes water began to trickle, and in a minute or two more there was a free flow. The power actually used on the pipe was about 20 horse-power. In the case of the first two services thawed out, during the operation I had my bare hand on the pipe, and only a slight warming up could be noticed.

We then decided to try less power, and went to work with the Edison direct 220-volt current. In this case we simply connected one end of a wire to one of the outside wires of the Edison system and the other end directly to the service pipe in the house; no further connections were made. A water rheostat in circuit

reduced the pressure to about 20 volts, and about 300 amperes were used. Under these conditions the longest time taken to thaw a service was eight minutes. All services were of lead.

I am satisfied that the practical way would be to have a portable plant, such as a gas engine and dynamo, capable of supplying 8 to 10 horse-power. That would undoubtedly be suitable for the purpose and would be entirely independent of electric light currents, or street railway currents, or anything of the kind, and the electricity could be made as wanted.

THE PRESIDENT. You think it would be perfectly practicable to employ a small gas engine?

MR. McINNES. That is the only way, sir; otherwise it is necessary to handle a current of high voltage, and you must have a man who knows how to do it. It is rather dangerous work except for an expert. I think it is practicable to have a gas engine and dynamo of 8 to 10 horse-power. We find that a current of 300 amperes and 20 volts produces the desired effect.

THE PRESIDENT. Have you had any experience on main pipes?

MR. McINNES. I have not, but I do not see why it should not work just the same.

THE PRESIDENT. You think the heating effect in a 6-inch main would be sufficient with that number of amperes?

MR. McINNES. No, you would have to increase your current, of course, to perhaps 700 or 800 amperes and use higher voltage as well.

THE PRESIDENT. If you were going to equip for thawing a main, you would need a larger apparatus?

MR. McINNES. For thawing mains, perhaps it would be better to use the Edison or the Boston Elevated current.

THE PRESIDENT. Have you tried it on a hydrant?

MR. McINNES. No, we haven't. We didn't appreciate the value of the method until the hydrants were thawed out. I don't know why it should not work.

THE PRESIDENT. I think it would be a very fruitful field for some of our electric friends.

MR. McINNES. Mr. Eldon, of the Edison Company, told me this morning that he was going to get up such an outfit and would advise his company to exploit it, as he thought it would more than pay for itself as an advertisement.

THE PRESIDENT. Well, it would not be an expensive apparatus, as I understand it, Mr. McInnes?

MR. MCINNES. I don't know what the cost would be, but it would exceed a thousand dollars. The plan we adopted was quite inexpensive.

MR. FREEMAN C. COFFIN. I should like to ask whether it is simply a question of more time unless you have a high voltage?

MR. MCINNES. That question I have been considering, and I have supposed it was, but those who watched the last thawing when I was absent say that they do not think so. I think that 7 or 8 horse-power is about as low as you could use, but I am not sure of that.

THE PRESIDENT. I should like to ask whether after a frozen service pipe is thawed it is not necessary to let the water run in order to provide against its freezing up again?

MR. MCINNES. It is necessary. We had that experience as well. We told the people in one house to let the water run, and they said they would let it run for the rest of the winter. On Dorchester Street we thawed out a pipe and advised that the water be let run, but some one inadvertently closed the cock within a minute or so, and in ten minutes it was frozen up again. My orders were to let the water run at least two hours.

MR. F. L. FULLER. Of what material was this service pipe?

MR. MCINNES. It was of lead.

MR. FULLER. Do you think a cement-lined pipe would offer any difficulty?

MR. MCINNES. Well, it would be a different problem. I don't suppose it would work so nicely as in the case of lead, but see no reason it should not be successfully done.

MR. A. E. MARTIN. In Pittsfield they have been thawing pipes in the same way. There, in the first case, they thawed 500 feet of 6-inch main in about five minutes. That can be verified, I am told, by the authorities there. And I also understand that in New Jersey they have had a little experience in thawing water pipes by electricity, having a machine which is mounted on wheels and a dynamo that they cart around the streets and use in that section. I was told that they had 700 frozen service pipes, and that they thawed them out at the rate of 100 a day.



TWO VIEWS OF BOILER USED BY MANCHESTER WATER WORKS.

A PORTABLE BOILER FOR USE IN THAWING FROZEN PIPES, ETC.

BY CHARLES K. WALKER, SUPERINTENDENT OF WATER WORKS,
MANCHESTER, N. H.

[Presented March 9, 1904.]

The accompanying photographs, Plate I, show a portable boiler which I have used for thawing the ground and frozen service pipes during the past winter and which has already paid for itself; it is also suitable for pumping water from a trench, for running a steam drill, or for other purposes.

The machine consists of a vertical boiler mounted in an iron frame with iron axles, with four wheels, arranged to be drawn by one or two horses.

The boiler is of ample capacity to furnish steam for the required purpose; it is 27 inches outside diameter, 46 inches in length, with 121 $1\frac{1}{2}$ -inch tubes, 26 inches long. It is covered with asbestos and wood lagging, and sheathed with planished iron. The top is fitted with a suitable smoke stack.

The boiler is fitted with fire door and grates, steam gage, gage cocks, safety valve, and injector. There are also fuel boxes on each side under the back axle. There is a water tank of sufficient capacity to furnish the water required for the boiler.

Arrangement is made for seat for the driver, with tool box underneath. The machine is also supplied with steam valves and connection to the hose for thawing out purposes; also, one 2-inch and one $\frac{3}{4}$ -inch ejector, with suitable suction hose and foot valve for lifting water out of trenches when required.

The total weight of the machine in running order is about 3 435 pounds.

THE LIFE OF CAST-IRON PIPE.

CONTRIBUTED BY MR. C. CAVALLIER, DIRECTOR OF THE FOUNDRIES
OF PONT-A-MOUSSON, FRANCE.

During the construction of the Metropolitan Underground Railway of Paris, it became necessary to remove one of the mains of the Vanne water supply, which, unlike many of the pipes of Paris water works, was laid in the ground, and occupied exactly the location required for the subway, for a distance of 1 200 meters ($\frac{3}{4}$ mile) along the Boulevard St. Jacques. This main was laid in 1874, and consisted of cast-iron pipes with bell and spigot joints, 800 millimeters (32 inches) in diameter, in lengths of 4 meters (13 feet). The disjoining was accomplished by cutting out the lead with chisels, after which the pipes were easily separated, the loss from breakage of pipes being only about 2 per cent.

All of the pipes had an interior coating of scale about 6 or 7 millimeters ($\frac{1}{4}$ inch) thick, which was easily detached with the hammer. The iron thus laid bare was in a perfect condition of preservation. Much of the coal-tar coating was still intact, and the numbers and weights marked in white lead were as clear as though just applied. The exterior of the pipes was also in good condition. The coating still remained on the greater part of the surface, while the balance had undergone a slight superficial oxidation. Remembering that these observations apply to pipes which had been in service, in the ground, for about twenty-eight years, after which they were in nearly as good condition as when laid, it is easily seen how safe and economical is the use of cast-iron pipes.

A still more convincing fact has recently been observed. The city of Paris, requiring the land occupied by the Chaillot pumping station in Place de l'Alma, has discontinued that station. This was the first station erected for supplying Paris with water. The intake consisted of flanged cast-iron pipes extending out into

the Seine, and, as it was no longer of any use, it has been taken up from the river bed.

The condition of these pipes after so long a period of immersion is a matter of considerable interest. They were in so good a state of preservation that they could have been relaid, but, as they were of antique type, they have been broken up and remelted. After removing the scale and the shellfish which had accumulated upon the exterior, the words "Creusot, an 10," in raised letters, could be easily read. This date corresponds to the year 1802 of our calendar.

The metal was a gray cast iron of excellent quality, the fractures of which were as sharp as of a piece just from the foundry. No alteration of either interior or exterior appeared after more than a century of submergence in the river.

Such a proof of the durability of cast iron requires no comments, but is certain to impress deeply all who are interested in the construction of permanent conduits for water.

NOTE ON OLD WATER PIPE SYSTEMS IN FRANCE.

Versailles, Marly, Meudon, and St. Cloud.

According to the Ministry of Public Instruction and Art, the conduits which supply the water to the great fountains in the park of Versailles are of cast iron, and date from the same period as the park itself. The most important are as follows:

Three pipes, 500 millimeters (20 inches) in diameter, 3 000 meters (10 000 feet) long, which bring the water from the Park of the Trappists to the reservoirs of Montbauron.

Two pipes, 500 millimeters in diameter and 2 250 meters (7 500 ft.) long, and 3 pipes 325 millimeters (13½ inches) in diameter and 1 500 meters (5 000 ft.) long, which convey the water from the reservoirs of Montbauron to the principal gate house.

Two pipes, 500 millimeters in diameter and 3 000 meters (10 000 ft.) long, and 1 pipe 325 millimeters in diameter and 1 500 meters (5 000 ft.) long, which bring water from the reservoirs of Gobert to the reservoirs of l'Aile.

All of these pipes were laid in 1685, or 219 years ago. The con-

duit of Chevreloup, from the reservoir of l'Aile to the Trianon, 325 millimeters in diameter and 3 500 meters (11 500 ft.) long, was laid in 1687, or 217 *years ago*.

Several old pipes of various diameters for conveying water from the reservoirs of Picardie to those of Montbauron, for distribution within the parks and in the town, and the spring-water conduit, having in all a length of about 8 000 meters (26 000 ft.), were laid between 1664 and 1688, or from 216 to 240 *years ago*.

All of these pipe lines consist of pipes one meter in length, joined by means of bolted flanges. They are of considerable weight, and still serve their purpose satisfactorily.

The few repairs which have been required have generally been necessitated by the bad condition of the flange bolts, which have rusted out.

Rheims.

According to Mr. Lamandiere, engineer and superintendent of the Rheims Water Works, the water supply of that town was established in 1748 by Mr. Godinet, canon of the cathedral. This system was in more or less regular service until 1840. At this time a new system, much better constructed, was built and is still in operation, although with considerable modifications and enlargements.

The distribution pipes in Canon Godinet's system were of lead. In building the pumping works some cast-iron pipes of the system built in 1748 were found. These were about 20 centimeters (8 inches) in diameter and 1.20 meters (4 feet) long, with square flanges. These pipes were in good condition when found.

Clermont-Ferrand.

Mr. Dalechamps, engineer and superintendent of public works of Clermont-Ferrand, furnishes the following notes relating to the old cast-iron water pipes of that town:

On December 5, 1730, a meeting of the town council noted that the conduit was considerably damaged. Sixteen years later, on September 14, 1746, the commissioners of fountains made an agreement with the Sieur Marchais, iron merchant of Paris, for

furnishing pipes of cast iron for the fountains. The works were constructed about 1748-49. The conduit, for a length of 1 570 meters (5 150 ft.), consists of 1 555 tubes 5 or 6 inches in diameter and 3 feet long. On the plain where the pressure is greatest the pipes are 9 lines (0.8 inch) in thickness, elsewhere they are 6 lines (0.5 inch) thick.

In 1867 the old conduit was paralleled by cast-iron pipes with lead joints, which was to supplement the old system. This is now out of service at several points.

The pipes were cast horizontally. The flange joints were made with a thick lead gasket, sometimes as much as 23 millimeters ($\frac{7}{8}$ inch) in thickness. The system is under a considerable pressure.

Saint-Etienne.

According to Mr. Andrieu, engineer and superintendent of public works of Saint-Etienne, there are in that city some cast-iron pipes which have been in service since 1782, or for one hundred and twenty-two years.

RATES FOR METERED WATER.

[*Topical Discussion, March 9, 1904.*]

Mr. FREEMAN C. COFFIN.* I suppose I am assigned to open this discussion because I am one of the members of the committee recently appointed by this Association to consider the rates for metered water. This committee as yet has done but little. We have had two meetings and discussed the matter somewhat. Whether we shall be able to do anything worth while remains to be seen. It is an important subject, and there are a great many sides to it. I think most of us believe that the extended use of meters, and perhaps the universal use of meters, is desirable and inevitable. Many of us consider the use of meters as a means of water-waste prevention rather than a matter of raising or securing revenue from water works. The prevention of the waste of water seems to be the most important function of meters.

There are used in different places from 20 gallons per capita to — well, it is difficult to say — perhaps 300 gallons of water per capita daily. There is a legitimate difference in the use of water. Some places use legitimately twice as much, perhaps three times as much, as other places. The per capita consumption tends to increase with the increase of population, due to the various uses of water that occur in a large place in excess of those in a small place. The larger the place, the more extended the use of water. Some communities actually use a large amount of water for manufacturing purposes. Generally speaking, however, large consumption, exceeding from 40 to 75 gallons per capita daily, is due to waste and not to use. In an ordinary town or city the actual use of water will probably not exceed from 30 to 60 gallons, or possibly, in extreme cases, 75 gallons per capita per day.

Some meters are used in all places to measure the water of large users, but regarding the meter as a means of preventing

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the waste of water, a community or water department when considering the general adoption of meters finds that one of the most important points to be considered is the effect of meters upon the revenue. A certain amount of revenue must be raised, and what is not received from the consumers must be raised by taxation. There is, of course, a difference of opinion in regard to the amount or proportion that should be raised by revenue and by taxation. That question is not the subject of discussion to-day, but when the amount is once determined that shall be raised by rates from the consumer, then upon the adoption of meters it is desirable that the revenues shall not become less than that amount; that is, there shall not be any deficiency. This has nothing to do, of course, with the question whether rates are high or low. That is another question, but certainly if meters are adopted, the revenue must be kept up. I don't know that there is any concensus of opinion in regard to what effect the adoption of meters will have upon the revenue. When rates are arranged upon a fixture basis, arbitrary and unscientific as it usually is, we know approximately what the revenue will be; but if we adopt meters, a change is made which may increase or decrease the revenue, and it is difficult to determine which.

Now, the question comes, How shall the revenue be raised, and how shall the meters be applied? Shall we endeavor to use meters upon all services, even those with one faucet only, or leave out the services with one faucet and apply meters only to services with more than one faucet? In many cases the minimum meter rate is fixed at \$10 a year. That, of course, shuts out single faucets in communities where the single faucet rates are about \$6. Now, a single faucet, under some conditions, causes a great deal of waste. Take a house where the pipe is not well protected from frost, and we all know that the waste caused by letting the water run to prevent freezing is very serious. It seems to me that, if possible, meter rates should be so arranged that meters can be placed upon single faucets. On the other hand, if we place the minimum rate at \$5 or \$6, in order to meter single faucets, houses with bath tubs, water closets, and set tubs, and all the appliances of modern comfort and luxury in the use of water, will pay their

\$5 or \$6, and, if they are very frugal, they will perhaps pay no more. The chances are they will not pay the \$14, \$15, \$18, or \$20 they are now paying.

The question is whether it is not perfectly reasonable and just, that without regard to the amount of water they use, houses having all these conveniences for the use of water should pay a larger amount than houses of only one faucet. It seems to me that it is. The water works are built at great expense to provide those things, and, to a certain extent, the greater the convenience and luxury derived from the water works, the greater the payment should be. That may not be possible under the minimum rate that admits of metering a single faucet.

Now there is a class of towns, of which we have a good many examples in Massachusetts, where there is a permanent population as distinguished from a transient population. The transients use more water in proportion while in town than the other people. In summer places, so-called, the consumption tends to be very large. If you have meters with a minimum rate of \$5 or \$10, whatever it may be, those people are rarely going to pay any excess, unless the excess is charged quarterly, because they are there only two or three months. Now, it may be said that a man who uses water only in the summer should not be charged so much as the man who uses it the year round, but that is not true; it costs just as much to supply a consumer with water for one month as it does for twelve months. The supply has to be as large, especially if the use of the water is in the summer, at the time when the supply is lowest; the piping must be just as large, the pumps and the reservoirs must be as large, and there is no difference in the fixed charges. We all know the fixed charges of a water system constitute the principal item of cost. If we include with fixed charges the salaries and operating expenses, which are not variable, the only cost that varies with the consumption is the cost of coal. The difference in coal for pumping is comparatively small, whether a man uses water in the summer only or in the winter as well. In some of these places the use of meters would reduce the tremendous waste of water that goes on. I have one place in mind where the daily consumption is about 300 gallons per capita in the summer time, based upon

the actual number of people there, not the permanent population. I know of another place of not over 2 500 people which uses 250 gallons per capita. This excessive use of water certainly requires the use of meters.

I believe that we all admit that the use of meters is the only practical means of restricting the waste. It can be restricted by a careful and persistent inspection, but that means a good deal of money, and it means much persistence, more than is usually devoted to it, and, in spite of inspection, waste will continue. It is, I think, fair to say that meters are the only practical way of restricting the waste of water. These places that I speak of require meters, but how can the rates be fixed? Although a very large amount of water is used in the summer for two or three months, the entire amount used in the year is small, and the revenue received at usual meter rates will not meet the expense of maintaining large works the year through in order to supply water for a few months. That is one of the serious problems of arranging meter rates.

Now, the question of the effect on the revenue, the question of the class of services which can be metered, and the question of the class of communities in which the meters shall be applied, — all these must be considered. As I have already stated, the committee which has been appointed by this Association has done very little as yet. It has sent out some blanks, and has received a great many replies. On the blanks were two questions in regard to receipts. One was whether a house with full plumbing under metered service in the particular town under consideration brought in a greater or less revenue than without meters. Most of the answers to this question indicate that the receipts are generally less.

Another question was, Is the total net revenue greater or less? The answers examined seem to show that it is less.

Now, I have taken the figures from the reports of Reading, Mass., and have made a diagram that shows the results graphically. This diagram (Fig. 1) shows what I am trying to indicate, namely, that upon the general introduction of meters the revenue decreases. The diagram covers the period from 1891 to 1903. It will be seen that the increase in the number of services is

quite uniform, and that the increase in revenue was quite rapid until 1887, at which time there were 20 per cent. of the services metered. During the next year the metered services were increased to 93 per cent., and the revenue fell from about \$8 150 to \$6 400, or more than 20 per cent. It began to rise again, the

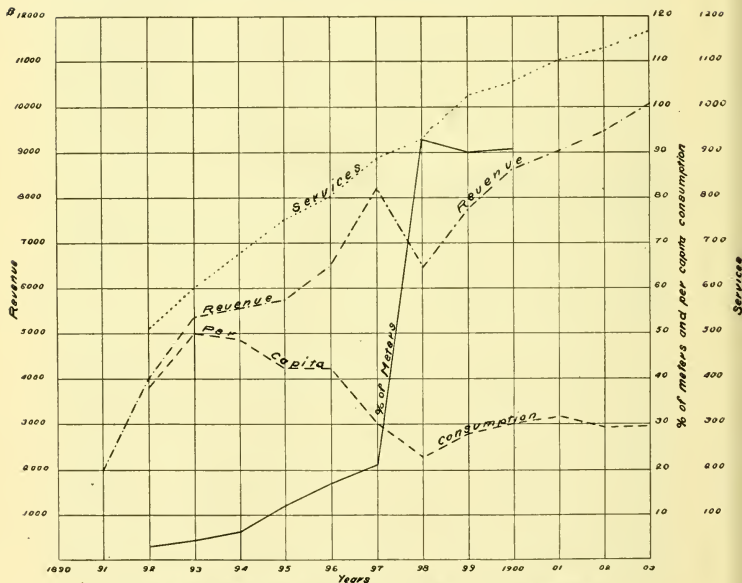


DIAGRAM SHOWING THE EFFECT OF METERS
IN READING MASSACHUSETTS

Fig. 1.

next year, but it was nearly three years before it was equal to that of 1887.

The diagram shows clearly the tendency of the revenue to decrease with a general installation of meters.

The committee on metered rates is not responsible for anything I say here, as I am only speaking as an individual. I want,

however, to make a certain suggestion as to a possible method of fixing meter rates, because I should like to have some discussion on it and see whether it is considered feasible, or whether it has been tried, and what the attitude of the Association would be towards it. I shall probably suggest this method to the committee for consideration: Take the case of established works, with a revenue based upon fixture rates when the adoption of meters is being considered; it may be done in the way I suggest and avoid a possible reduction of revenue and also cover some of the other points that I have raised. The suggestion is that the fixture rates in use be continued without change; the meter to be used simply as a means to check the waste. That will leave practically the same revenue which they have been receiving, except where there is an excess used. It might be wise to make a reduction in the fixture rates of 5 or 10 per cent. as an inducement to the consumers in the adoption of meters. Under my suggestion it is assumed that the department will own the meters, and make no charge for rent; it might or might not require a deposit. Then put on meters wherever the consumers desire them, or wherever the department desires them, — it should, of course, be at the option of the department where the meters are to be placed, — and read them quarterly. Now, each consumer shall have the right to use without excess payment an amount of water which at the meter rates will correspond to the sum he pays; that is, if he has one faucet, and he pays \$6 for the water, he may use each quarter \$1.50 worth of water without further payment, but if he uses any more than that in any quarter, he will pay for the excess. The bill perhaps would not be collected in that quarter, but that would be a matter of detail. The rates may be collected as now. If collected in advance, the fixture rate would be paid, and if an excess is used, that might be paid for each quarter or at the end of the year.

The meter rate may be arbitrary, as now, or based upon the cost of supplying the water. In the latter case the price, of course, would differ in different places, and in some places a consumer would get more water for his fixture rates than he would in others; that depends largely on natural conditions. This is about all there is to the suggestion. It is simply a device

to avoid some of the difficulties that are met in adopting meters. In case of towns that have a large summer population, the consumers would pay their fixture rates, and if they came in the summer and used a large amount of water, they would pay for the excess water they used in that quarter.

There may be a great many objections. I am making this suggestion in ignorance, and I hope it will be discussed; it may be of some use and it may be of no use. At any rate, it would, I believe, cover the case of summer places, and it would, above all, determine in advance something like what the revenue would be, and it would be effective in reducing the waste of water, which is what we are really after in the metered system.

I hope the other members of the committee will have something to say from their standpoints. As I have already said, this is what I have to offer individually, and what, to a certain extent, I may offer to the committee later.

MR. H. V. MACKSEY.* Before we can hope to offer anything to be generally adopted, it would be well if we can find out the view taken by the members of the Water Works Association. I have been unable to learn whether a water works is supposed to be a public service corporation or an eleemosynary institution.

If we discuss the subjects of rates with men who represent certain cities and towns, and ask them why they are serving water at different prices to different classes, they argue that it is not fair to charge all alike. The wealthy man who owns a residence with high valuation, they say, can afford to pay more than a man who lives in a little shack and has but a single tap. Yet in some towns and cities where they adopt this method of assessing rates, when the wealthy man's property reaches a certain valuation, they cease to base assessment on that valuation. There is a maximum valuation, and they consider one man too wealthy to tax and one too poor to tax, and it is the unfortunate middle class which gets ground in between their two systems.

My personal opinion is that water as supplied by cities, towns, or public service corporations should be supplied at the same price per quantity to all takers, and that if it is necessary to take care of the poor, it should be done directly and openly

* Deputy Superintendent of Streets, Boston, Mass.

through general taxation and not by an institution that is supposed to be run on a business basis.

We find also another objection. We are told that if we put meters on all services and compel the large manufacturer to pay at the same rate for water that the small taker does, we shall drive the large manufacturer out of that town, and consequently many of the residents will be put out of employment, and we are told that other towns and cities will take that factory, giving it land and taxes free. If cities and towns wish to do that, very well, but they should not charge this tax up to the small water taker.

I think the proper way to sell water is to sell it at a uniform rate, making that rate as low as possible, and meter every service. Yet I cannot find many who agree with me. The scheme laid down by Mr. Coffin is practical. The only weak feature we can see at present is that we must find money to cover first cost, inspection, and maintenance of meters. That money must be provided in some way, and if you tell a water taker that he must pay that expense, he opposes meters as an expensive luxury. If you ask a city or town to supply the money from general tax levy, they ask you to earn it all. This scheme proposed a reduction in rates. In the meantime, you must have money to buy and install meters.

There was another scheme proposed by a member of the committee, whom I do not see present, that there should be a service rate, every service being metered; a certain fixed charge for each rate of service, including meter, should be made, and a uniform rate for water in addition. That seems to be approved by a number of persons with whom I have talked. That scheme seems feasible in very many cases. The only difficulty is the provision of money to establish meter service.

Eventually we will reach a point where we must install meters and sell water at a uniformly fair rate to all. Takers will not stand different rates on metered water any more than they will on metered gas. We must get down to a basis where we treat every one alike. If it is a temporary expedient to get meters started on the plea of waste and not service, I think the plan laid down by Mr. Coffin very good and feasible.

MR. CALEB M. SAVILLE.* I think the subject has been well gone over by others, and especially so by Mr. Coffin. The scheme which Mr. Macksey has just spoken of may be worthy of consideration, but I do not think it is anything more than a suggestion. Perhaps it is well that it is given here, and then leave it open for discussion.

I have outlined a method which I should like to have considered by the members.

When changing from a fixture to a meter system of assessing water rates, it is undoubtedly desirable to make as little disturbance as possible in the existing rates.

Most rate payers expect a reduction in the water bill after a meter has been installed, and are sure that the meter is incorrectly registering if they are disappointed. In some places a handsome profit is obtained yearly from the conduct of the water works, but in most municipal works the rates are so low as hardly to pay all the demands upon them. In such cases it is hard to see how a still further reduction can be made and yet have the works self-supporting. In many cases undoubtedly this could be done if the works were run on the economical basis they would be if under private management.

The items of construction and extension, belonging wholly to new work and constituting additions to the plant, it is not necessary to consider here, as it is generally conceded that they may equitably be met by bond issue and become a charge on future generations. If this be granted, the principal items of expense to be met yearly are:

- (1) Office expenses, meter reading, maintenance, and renewals.
- (2) Interest on bonded debt.
- (3) Payment to sinking fund.
- (4) Pumping and other costs directly affected by quantity of water used.

There seems to be no question that the present practice of fixture rates is illogical and has no basis for consideration at this time, when means for accurately and cheaply measuring water are at hand.

After a service is installed it is just as much work to maintain

* Division Engineer, Metropolitan Water Works, Boston, Mass.

it, whether it passes ten cubic feet a day or one thousand, with the exception that the investment and repair in the case of the larger meter is somewhat greater than in the smaller ones. This item could be adjusted readily in the scheme outlined below. On account, therefore, of the nature of the charges in Item 1, it seems equitable that they should be divided equally among all services (excepting as modified by size of meter). The other three items are governed in more or less degree by the quantity of water required, and therefore might be charged for at a flat rate per 1 000 gallons or per 100 cubic feet.

In brief, the proposed agreement would consist of two parts:

(1) Expense for office, meter reading, maintenance, and renewals divided by the total number of service connections, this to be a fixed charge for every service.

(2) Expense for pumping, interest on bonds, and payment to sinking fund divided by the net amount of water supplied to the town or city (*i. e.*, total of the service meters, assuming that all services are metered), each rate payer to be charged at this rate for the quantity of water registered on his meter.

The above plan would avoid all expense for survey of premises to determine a rate, and no readjustment would be necessary if new fixtures were added or old ones abandoned. Each consumer would be treated exactly as every other, and only such water as was actually used would be paid for.

Under this system (no minimum rate and no allowance of water) it would not be necessary to collect rates quarterly in order to forestall the saving of water for summer use, as is frequently done under minimum rate payment, because all water used would be paid for. This would be a considerable saving in clerical expense, as only bills to large consumers under this plan would need to be rendered quarterly. Rates should be payable in advance, with an adjustment at the end of the year, a discount, perhaps, given for prompt payment, and a fine for those who are dilatory. No rebate should be given except for incorrect registration by the meter, which should be owned by the water department. A flat rate should be paid for all water used, from the least to the greatest amount, — the nature of the use and the benefit obtained from the supply offsetting the

advantages supposed to accrue from the sale of large quantities to a single consumer.

In a town or city contemplating a change from fixture to meter rates, under this plan the present expenses would be taken as a basis, and the rate per thousand gallons adjusted to return a sufficient revenue. The cost of meter installation should properly be charged to construction or extension, and be met out of the proceeds of the bond issue.

All water should be paid for just as any other commodity, and no distinction made. If it seem best to make certain classes of property bear a greater share of the cost, a portion of the expense, as payment to sinking fund or interest on debt, might be assessed either on street frontage or real estate valuation. This would seem just, as the convenience and luxury undoubtedly are of value, and should be paid for by the consumer. If a portion of the rates be so assessed, the difficulty experienced with the single faucet payer will be overcome, and he, too, will pay only for the water used.

By assessing a portion of the rates on frontage or valuation, the summer resident would have to pay his full share toward the conduct of the works. The yearly cost of maintenance of the system for the few months he uses the water then would be met by the fixed charge, the water would be paid for in proportion to the quantity used, while the advantages incidental to a full supply of water would be met by the real estate amount.

MR. C. R. FELTON.* There is one thing in relation to Mr. Coffin's diagram which strikes me forcibly — he shows a decided decrease in revenue. If the people get just as good service and use just as much water as they need under the meter system, it must be conceded that while the city or town may have lost through the decrease in revenue, it was certainly saved to the people who pay the water bills.

In addition to this, in the case of a city or town nearing the limit of its supply, if interest and sinking fund on a new supply for several years could be saved, it might make a very different showing so far as net revenue is concerned.

* City Engineer, Brockton, Mass.

In the case of our own system, had we used anywhere near the amount of water used in other cities, we should have had to secure a new supply ten or fifteen years ago.

The following table shows the consumption of water in Brockton since 1892, which was the first year that records were available, the pumping-plant being installed at that time:

Year.	Population.	Total Consumption (gallons).	Daily Consumption in gallons per capita.	Domestic use in gals. per capita.		Manufacturing (gals. per capita).	Street sprinkling (gallons per capita).	Fountains (gals. per capita).	Unaccounted for (gallons per capita).
				Metered	Un-Metered				
1892	29 643	271 652 000	25.0	—	—	—	—	—	—
1893	30 817	264 409 000	23.5	—	—	—	—	—	—
1894	31 993	323 201 000	27.7	6.7	3.8	—	—	—	—
1895	33 165	399 694 000	33.0	7.3	3.2	2.4	1.8	1.5	16.8
1896	34 544	403 882 000	32.0	9.2	3.3	3.2	2.2	1.4	12.7
1897	35 923	386 428 000	29.5	8.5	2.6	4.0	2.8	1.4	10.2
1898	37 302	369 370 000	27.1	10.3	2.8	2.7	2.2	1.3	7.8
1899	38 681	414 737 000	29.4	11.0	2.7	3.6	2.6	1.3	8.2
1900	40 063	429 002 000	29.3	10.9	2.5	4.0	2.5	1.3	8.1
1901	41 610	447 500 000	29.4	11.5	2.1	4.0	2.4	1.4	8.0
1902	43 159	506 800 000	32.2	12.8	1.4	4.2	2.2	1.6	10.0
1903	44 704	537 800 000	33.0	13.5	1.7	4.9	2.1	1.6	9.2

We have about 90 per cent. of our services metered, and our consumption for the last ten years has not exceeded 33 gallons per capita daily. I should say that perhaps 90 per cent. of the population are consumers. Up to 1892 we had no system of sewers. It has always been argued that as soon as you get a system of sewers, the water consumption is going to materially increase. The first years that we had any sewers the water consumption rose to about 33 gallons per capita, and we ascribed it more or less to the new sewers, but the next year it went back to 32 gallons, and the next year after that to 27 gallons, and we have never had a consumption of over 30 gallons per capita since that time until within a year or two. We now have a daily consumption of about 33 gallons per capita, but of this there are about 8 gallons which we cannot account for, and, in my opinion, it is due to leakage from the system through services and mains.

I agree with what a previous speaker has said, I think there should be a flat rate for metered water,— that every one should pay the same amount for water used, but we do not do it that way; the usual rate of 30 cents per thousand gallons is decreased for large users, and the manufacturers have a maximum rate of 25 cents per thousand gallons and a minimum rate of 15 cents per thousand gallons.

MR. FRANK E. MERRILL.* Mr. President, I think Mr. Coffin's paper and Mr. Macksey's remarks have covered the subject matter which has been before the committee so thoroughly that I don't know that I have anything to add on that topic. I agree very largely with the statements made by those gentlemen with the conditions that they bring up.

The meter system in Somerville is in its infancy. I think we are alive there to the importance and the advantages of such a system, but we have not as yet acquired very much experience, as our domestic meters have been in operation hardly a year.

I am one of those who agree with my friend Macksey in believing that the rate should be a flat rate, and should be made as low as possible. I always felt that it was a discrimination against householders — whom the water supply of a city is supposed to primarily benefit — to charge them for the small amount which they require a larger price than is charged to manufacturers for the use of water in their business, and I am pleased to say that we have this year in Somerville changed our basis of assessing rates from the graded scale to practically a flat rate. The old rate was 14 cents per 100 for the first 20 000 cubic feet used in a quarter, 13 cents for the next 20 000, 12 cents for the next 960 000, and 8 cents for quantities above that. Our rate now, since the first of January, is 12 cents per 100 cubic feet for all quantities less than 1 000 000 cubic feet used in a quarter, which covers practically everything in our city, as we have but two or three customers who use larger quantities than that.

I think in another year, Mr. President, I shall have acquired some experience, and may have something of greater interest to offer to the members of the Association than I have to-day.

* Water Commissioner, Somerville, Mass.

MR. ANDREW D. FULLER.* Mr. President, I think it is the duty of a town to introduce meters for the purpose of establishing, as Mr. Macksey said, a method of giving each consumer the water for which he pays. I have had occasion to see the waste of water, especially from the tap end of the system. If the plant is well constructed and in repair, the real waste is caused by the public, and I think it is to the public only that you can look to stop the waste. I have found that there is a large difference in houses of the same class in the per capita consumption, and this applies not only to the expensive houses, the houses of the rich, as you might say, but also to the houses of the middle class. I will give two illustrations which occurred last summer. One was in a house where the consumption was 11 000 gallons a day. The consumption was far too large even for that house. On investigating the conditions, I found there was an actual leakage through the house of 6 000 gallons a day. I am very certain that would never have been found if the man had not had a meter and had not been obliged to pay on the metered rate. He said it was on account of the excessive water bill that he caused an investigation to be made. Now take a house of another class, where the house consumption was never over 200 or 250 gallons a day; the hose in one hour ran 600 gallons.

I think we all appreciate green lawns, but to any one who has examined the various lawns it is perfectly apparent that there is a great waste there. By continually watering the lawns the ground gets very moist, it is easily dried in the sun, and the roots come to the surface, so that to keep the lawn green it is necessary to continue excessive watering. If the man had had to pay by the meter, he would have shut off the hose on the time limit fixed by the town; you know that depends on the inspectors.

There is another duty which we have to perform, and that is from the sanitary standpoint and also from the question of comfort. It is true that the fixtures in the house are not multiplied as much as they would be if a man was paying on a metered rate for the water that he used. It is true that with the multiplication of fixtures the use of water increases in the house,

* Civil Engineer, Boston, Mass.

but the increase is not proportional to the increase in fixtures. This is something which, from a sanitary point of view, should be encouraged, that is, make it as convenient as possible to use the water for washing and domestic purposes. From the other side, I think, as we have accepted the ordinary rule of assessment, a man should pay according to the benefits received. It is only fair that he should do so.

MR. WILLIAM PAUL GERHARD.* Mr. President, I am not prepared to say much on this question. I am not connected with water works directly. However, I have a great deal to do with the installation of water pipes in houses, and I would say that in New York City, in new buildings of large size and also in many private houses, with which I have largely to do, we always set a meter, and the cost of the meter is paid by the owner. We do not find any difficulty; the owners don't seem to object to it at all. I have no doubt that the results attained are beneficial in checking waste, and we find very little complaint from the owners in regard to exorbitant bills.

Talking about fixture rates, I might, perhaps, in connection with that, relate a peculiar experience which I have had. About twelve years ago I moved to Brooklyn, now consolidated with New York, and in my small house I had one bathroom with three fixtures. The rates were by frontage and by the number of stories, a fixed rate, and in addition for each fixture after the first, they charged a fixed sum per year; that is, for a bath tub more than the first bath tub, they charged a fixed sum. I got it into my head to try in my bath room a little fixture—it is called a bidet. It is a small vessel which you can use for a foot bath or other purposes, and it uses not more than a gallon or so of water. The water inspector came there, and when the next bill came around, I was charged for two bath tubs. I went to the water department and mildly objected. I argued that if I really had two bath tubs in my house, as the bill claimed, certainly two people should be able to take a bath at the same time, that is, that there would have to be two different bath rooms, which was not the case, and I explained the character of this little fixture, but for year after year I have paid for two bath

* Consulting Engineer, New York City.

tubs, although I have but one in my house. I might add that since Brooklyn was consolidated with New York this has been changed, and the bidet is not now charged for.

MR. JOHN C. CHASE.* Mr. President, my voice has been heard here so often in favor of the general use of water meters, that I hardly think that I can add anything new on this well-threshed subject.

The gentleman who spoke a few minutes ago said he was in favor of water meters because a man then got what he paid for. I am of the opinion that the average non-metered consumer generally gets a good deal more than he pays for, or would use if he had to pay by the quantity instead of by fixture, and that the main object of the meter is to insure the supplying agency getting paid for the water used. The equitable adjustment of the water tax is also an important function of the meter.

I happen to be officially connected with two water supply companies. With one I had nothing to do with its inception or the establishing of the rates and regulations. Meters are not sanctioned except where the water is used for manufacturing or commercial purposes. I am certain that a general use of meters would have saved us quite an expenditure of money in increasing our supply, and our receipts would be more equitably derived from the consumers. In the other concern with which I am connected, meters were put in use to quite an extent when the works were first started, over twenty years ago. We began with furnishing the meter free to the consumer, except for a fixed charge of \$2.50 for setting and boxing, which was a very radical departure for a water company, or for a municipality, for that matter. A fixture rate was provided for dwelling houses where it might be reasonably assumed that the legitimate use of water would have a fairly close relation to the number of fixtures and the size of the family. All other consumers were required to have meters, and any consumer could have a meter provided a minimum rate of \$10 per year would be paid. The result is that practically all consumers whose fixture rate would be more than \$10 per year elect to have meters, and about 70 per cent. of the services are metered. The general price for

* Civil Engineer, Derry, N. H.

metered water is 20 cents per thousand gallons, and one year the metered water averaged a higher price than that, on account of the large number of consumers whose use did not amount to that allowed for the minimum charge. At the same time the unmetered water only brought us an average price of 6 cents per thousand gallons, after a liberal deduction for the estimated quantity used for fires, leakage, and slip of the pumps. As the cost of the water delivered to the consumer was some 8 cents per thousand gallons, it will be seen that the unmetered water was being sold for less than cost, while the metered supply footed the bills.

I am a firm believer in the meter being owned by the water department, whether public or private. It can then be inspected and repaired at the option of the owner, with much less chance for friction or complaint. It is virtually done at the expense of the consumer in any event, as he pays for it in an increased tax levy if a municipality owns the works and in a higher price for the water if it is a water company; and if it is an indirect charge, it attracts much less attention. Personal experience upholds the opinion expressed. Our meters are watched closely, and when a decreasing registration is indicated, the meter is removed, and the necessary repairs made to bring it up to its original efficiency.

The question of rates is largely of local application, and no hard-and-fast rule can be made that will apply to all places. It goes without saying that the average domestic consumer can afford to pay a higher price per thousand gallons than the manufacturing or commercial consumer. At least the domestic taker cannot easily get his supply from any other source, while the manufacturer may quite likely avail himself of a supply that would not be suitable for domestic use, and at a price much lower than the water company would be justified in accepting.

I am inclined to believe that the same meter rate should be charged for all commercial or manufacturing purposes without reference to the individual consumption, making a distinction of class rather than quantity. I may also say that it is plainly evident that the meter has come to stay, and that a generation hence its non-use will be as rare as its use when my attention was first

drawn to the subject some thirty years ago. I am not prepared to advocate their use on services with a single faucet for domestic use, as the expense of maintenance of a meter is too large a proportion of the gross receipts, and a reasonable inspection service will reduce the probable waste to a minimum. They could be applied, however, in such cases, whenever it was thought best to correct any abuse of the single fixture privilege. The general use of meters will come as the result of educating the public up to the point that it is the only equitable way of apportioning the rate and preventing an abuse of privilege.

MR. JULIUS C. GILBERT.* Mr. President, I am a believer in meters; still, I think I should hardly believe in metering all the faucets in a country town. We have in my town between 1 000 and 1 100 services, and 50 per cent. of them are metered. If we undertook to make a flat rate for water for every one, I think we should get into trouble. We charge 30 cents per 1 000 gallons, provided a consumer does not use over 1 000 gallons per day. If he uses over 1 000 gallons per day, he has it for 25 cents per 1 000 gallons; if over 2 000 gallons, 20 cents; and if over 3 000 gallons, 15 cents per 1 000 gallons. Some years ago we had the New York, New Haven & Hartford R. R. as a customer. They thought they ought to have their water — they used a large quantity — for 12 cents per 1 000 gallons, and we refused to allow them to have it at that price. Consequently, they laid pipes to a small meadow pond and we lost them as a customer, which took away something like \$1 000 per year of revenue. We also have quite a number of large shoe factories. Some of them wanted water at a cheaper rate, and we refused to give it to them for less than 15 cents, and they drove wells and are pumping their own water. By not reducing the rate to them we lost something like one quarter of our revenue.

It seems to me that if you undertook to make a flat rate in any country town, it would work just the same as in other towns as it did in ours if you refuse to cut the rates to large consumers. There are many places in town where it would not be profitable for us to meter the water. I have in mind one block in particular where there are a great many offices and stores and

* Treasurer Whitman (Mass.) Water Works.

fixtures of different kinds, washbowls and water closets, which we have had the good luck not to be asked to meter. In such a block as that, you all know, if a man has an office, that really he would not use \$3 worth of water a year, or even perhaps more than a quarter of that, while we get \$6 for each one of those faucets all through the block.

In another instance we had a double tenement house which was paying us from \$12 to \$20 a year, and we put in a meter and now we only get \$6 for the water. And, by the way, we charge them 39 cents per quarter for a common five-eighths inch meter. From these double tenement houses in our town we only get about \$6 for both tenements, for the reason that they are occupied by, perhaps, a man and his wife, both of whom work in the shop, and the amount of water they use is very small indeed. We have a number of those cases where it reduces our revenue very much to put in meters. Still, as our supply was very short, we have put them in, and we shall continue to do so.

We have in the past two years put in meters on all the new houses that have been built, because they all have bath tubs and water closets, and, of course, they don't want to pay the faucet rates.

It seems to me there is a great difference in towns. We could hardly make a rate which would be applicable to all the towns in New England. Whatever this Association might decide upon as a proper rate, most towns would feel that they should be governed more by the local conditions than by anything that this Association might do. I like the idea of Mr. Coffin, but still I hardly think it would be applicable to all places. I only wish that we could all have a water supply that we could get by gravity, and then we would get a good income and we could please all the people. I am troubled a great deal with complaints about the water bills. If a man has a little larger bill one quarter than usual, he thinks he knows a great deal more about the amount of water he is using than we do when we read the meter. I have often told them that I don't see any use in having meters if a man who had water in his house could tell every quarter just how much he used.

Now, another thing which affects the consumption of water a

great deal is the use of water on lawns. Our works have been in about twenty years; the first few years everybody flooded the lawns — you could see water running down the street everywhere, nights and mornings. Then we passed a vote in town meeting that hose should be used only two hours per day, at night, and before eight o'clock. We did the best we could, but I found the hose all running at eleven and twelve o'clock at night, and they all thought they were smart to do it. You all know how that is. We have many good men in the town, but they will get all the water they can for nothing. I guess that is about so everywhere. I am inclined to think that the only right way is to meter water, but still I think that if a man uses a great quantity, we have got to let him have it at a less rate than a man who does not use more than \$5 or \$6 worth.

MR. JOHN O. HALL.* Mr. President, this matter is of vital importance to the water-works man. It seems to me that every one who has spoken has rehearsed the difficulties under which he has labored, and yet not one has touched the keynote of the whole difficulty. The duty resting upon water men, upon public servants, is to administer their affairs for the interest, the profit, and the welfare of the entire community. The whole difficulty, as it seems to me, is that they are confusing the method of administration. I believe in Massachusetts the question presents itself in this way: The community pays for the establishment of the plant. The cost of the establishment should go into the general tax levy, and in that way it is divided fairly. The vacant land in any community is enhanced in value by the establishment and maintenance of a good water plant. Then the men with large properties, or the corporations with valuable plants, pay their proportion in the general tax. Then, for maintenance, every individual pays for the water which he uses. That can only be accomplished fairly by measuring, as accurately as possible, the water which he uses, costing that community to furnish so much per gallon. After you have provided for the expense of the establishment of the plant, dividing it among the individuals in that community, you have then eliminated from the question much of the difficulty.

In Massachusetts we are allowed to tax \$12 on a thousand

* Ex-Mayor, Quincy, Mass.

for the current expenses of a community. We are allowed in addition to tax for the municipal debt, water debt, sewer debt, and everything of that sort. We charge that amount into our annual tax levy. Now, the individuals pay, in addition to that, for the maintenance of the water plant each year. If you establish meters and one man uses 10 000 gallons and another 1 000 gallons, one man pays at a fixed rate the cost of furnishing him with 10 000 gallons and the other man pays the cost of furnishing him with 1 000 gallons. The establishment of the plant has already been provided for, and has been eliminated from the account.

I do not believe in a flat rate. I do believe in assessing to each individual the cost per gallon of the water which he uses, and under those circumstances he cannot complain. The actual experience is this: We assess a fixed rate for water, which is guessed at, one man paying, say, \$5 for so many fixtures, another man, without any knowledge of what he uses, pays another sum, and the result is an accumulation in excess of the expenses of the water department, which the legislative body will proceed to appropriate for other expenses of the municipality. The result is that in every community there is transfer from the receipts of water, amounts varying in different communities, but exceeding, to a large extent, in a great many communities, the amount which the statute allows them to tax to the city. I believe the only proper course is to put into the general levy the cost of construction, apportioned upon all the valuation, and then charge the individuals for the water which they use. Adopting that principle, you have simplified the question, you have made it fair, just, and equitable to every community, large and small. Adopting this policy may result in a reduction of revenue, but it will also result in a reduction of expenses; any expense will be divided as the *actual* cost and not an amount which is guessed at, which will yield an excess of revenue over cost, which may be at the disposal of the legislative body.

I believe it is the business of the water department to stand firmly to this principle: That the water should be furnished to the citizens at its cost, and that no profits should result from the administration of the water department which can be appropriated or applied to any other purpose.

PROCEEDINGS.

MARCH MEETING.

HOTEL BRUNSWICK,
BOSTON, March 9, 1904.

President Brooks in the chair.

The following members and guests were present: —

MEMBERS.

S. A. Agnew, F. E. Appleton, C. H. Baldwin, L. M. Baneroft, J. E. Beals, George Bowers, E. C. Brooks, Fred Brooks, C. F. Chandler, J. C. Chase, F. C. Coffin, M. F. Collins, G. E. Crowell, A. W. Dean, L. N. Farnum, August Fels, B. R. Felton, C. R. Felton, J. H. Flynn, F. F. Forbes, A. D. Fuller, W. P. Gerhard, J. C. Gilbert, D. H. Gilderson, A. S. Glover, F. W. Gow, R. A. Hale, J. O. Hall, J. C. Hammond, Jr., T. G. Hazard, Jr., F. W. Hodgdon, H. G. Holden, J. L. Howard, Willard Kent, C. F. Knowlton, E. S. Larned, G. A. King, A. E. Martin, W. E. Maybury, F. E. Merrill, A. G. Pease, H. E. Perry, Dwight Porter, W. W. Robertson, C. M. Saville, S. P. Senior, C. W. Sherman, A. T. Safford, G. A. Stacy, G. T. Staples, F. P. Stearns, J. T. Stevens, W. F. Sullivan, C. N. Taylor, R. J. Thomas, W. H. Thomas, J. L. Tighe, W. H. Vaughn, C. K. Walker, G. E. Winslow, E. Worthington. — 61.

HONORARY MEMBER.

F. W. Shepperd. — 1.

ASSOCIATES.

Builders Iron Foundry, by F. N. Comet; Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; Hersey Mfg. Co., by Albert S. Glover, James A. Tilden, W. A. Hersey; Henry F. Jenks; Kennedy Valve Co., by M. J. Brosman; Lead Lined Iron Pipe Co., by T. E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; H. Mueller Mfg. Co., by W. L. Dickel; National Lead Co., by G. L. Whittemore; National Meter Co., by Charles H. Baldwin and J. G. Lufkin; Neptune Meter Co., by W. H. Van Winkle and H. H. Kinsey; Norwood Engineering Co., by H. N. Hosford; Perrin, Seamans & Co., by James C. Campbell; Rensselaer Mfg. Co., by Fred S. Bates; A. P. Smith Mfg. Co., by D. F. O'Brien; Sumner & Goodwin Co., by H. A. Gorham; Sweet & Doyle, by H. L. DeWolfe; Thomson Meter Co., by S. D. Higley; The William Tod Co., by Irving H. Reynolds, Fred C. Gifford. — 25.

GUESTS.

Charles E. Harris, Superintendent Water Co., Rockville, Conn.; W. O. Mudge, Water Registrar, Lynn, Mass.; F. L. Weaver and R. J. Crowley, Members Water Board, Lowell, Mass.; J. F. Gleason, Quincy, Mass.; Alex MacPhail, Hingham, Mass.; Morris F. Whiton, Treasurer Water Co., Hingham, Mass.; John J. Moore, Hingham, Mass.; E. D. George and Frank Pease, Merrimac, Mass.; George E. Waite, Providence, R. I.; Mr. Dickens, Newburyport, Mass. — 12.

(Names counted twice. — 2.)

The following applicants, being recommended by the Executive Committee, were elected to membership: —

Elisha F. Haywood, Water Commissioner, Woburn, Mass.; Redmond E. Walsh, Water Registrar, Woburn, Mass.; Timothy V. Sullivan, General Foreman Meter Service, Boston Water Department, 1413 Washington Street, Boston, Mass.; Oren E. Parks, City Engineer, Westfield, Mass.; J. Emile Vanier, Chief Engineer cities of St. Henry and St. Cunegonde, also towns of Maisonneuve, St. Louis, and Valleyfield; address: 107 St. James Street, Montreal, Canada.

Mr. Charles K. Walker showed photographs of a boiler used by him for thawing frozen ground, hydrants, pipes, etc.

Mr. Charles H. Eglee, Hydraulic Engineer, of Boston, addressed the Association on the subject of "Experiences."

A topical discussion was opened by Mr. Freeman C. Coffin, C.E., of Boston, on "Rates for Metered Water," which was continued by Messrs. H. V. Macksey, Caleb M. Saville, F. F. Forbes, C. R. Felton, Frank E. Merrill, Frank L. Fuller, Andrew D. Fuller, William Paul Gerhard, John C. Chase, Julius C. Gilbert, and John O. Hall.

Mr. Frank A. McInnes, of Boston, gave an account of his experience during the past winter in thawing water pipes by electricity.

A paper prepared by Mr. Edward H. Cowan, Superintendent of Water Works, Marion, Ohio, on "The Detection and Prevention of Water Waste at Marion, Ohio," was read by Mr. Charles W. Sherman.

Adjourned.

EXECUTIVE COMMITTEE.

MARCH 9, 1904.

Present: President E. C. Brooks and Messrs. Bancroft, Beals, Hammond, Holden, W. Kent, Merrill, Sherman, and Thomas.

Five applications for membership were received and approved.

WILLARD KENT, *Secretary*.

OBITUARY.

JOHN C. BROATCH, Superintendent of Water Works at Middletown, Conn., died on April 2, 1904.

He was born in Middletown on March 14, 1843. He served throughout the Civil War in the Second and Fourteenth Connecticut regiments, and rose to the rank of major, with the brevet rank of colonel.

On February 4, 1871, Major Broatch was chosen Secretary of the Board of Water Commissioners and Superintendent of Water Works at Middletown, and held this position continuously until his death, with the exception of a single year. He also served in the state legislature in 1887 and 1888.

Mr. Broatch was elected a member of the New England Water Works Association on April 21, 1885.

NEW ENGLAND WATER WORKS ASSOCIATION.

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No. 3

This Association, as a body, is not responsible for the statements or opinions of any of its members.

THE DRIVEN WELLS AT THE MT. WASHINGTON,

A HOTEL AT BRETTON WOODS, N. H.

A CORRECTION.

BY WM. PAUL GERHARD, CONSULTING ENGINEER, NEW YORK CITY.

[June 25, 1903.]

In the discussion on the paper by Mr. George Bowers, City Engineer of Lowell, Mass., on "Underground Water," which appeared in the June, 1903, number of the JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, I find reported certain statements by Mr. Charles N. Taylor, Contractor and Engineer, of Wellesley, Mass., which contain errors that seem to call for a correction. I greatly regret not having been present at the meeting to answer Mr. Taylor then and there and to correct those errors.

First of all, let me state that I was the engineer selected by the Mt. Pleasant Hotel Company to prepare plans and specifications and superintend the construction of their new water-works plant at Bretton Woods, N. H.

The true history of this little plant is as follows: Before the new hotel called "The Mt. Washington" was contemplated, the other hotel of the Mt. Pleasant Hotel Company, "The Mt. Pleasant," was supplied with water from a deep artesian well with a steam pump; the depth of this artesian well is stated variously at 396 and 408 feet. Besides this deep well the company had seven other shallow driven wells in a basin of gravel near the golf grounds of the hotel. These wells varied in depth from 20 to 23 feet; they were $2\frac{1}{2}$ inches in diameter and were reported to yield an average of about 20 gallons per minute each. Owing to the large consumption of water, it was necessary to keep the artesian well pump, as well as the electric pump operating the shallow wells, going about eighteen hours a day.

When I was requested, in 1901, by the company to take the matter of water supply in hand, it occurred to me, after a preliminary survey of the locality, as the first thing, that if it were possible to obtain from some mountain brook a gravity supply sufficient in quantity for the new, as well as the old, hotel, this would be the most desirable plan, as it would do away with the cost and nuisance of pumping. I at once arranged for proper surveys to be made for a new supply, in which I was ably assisted by Mr. Ray T. Gile, Civil Engineer and Surveyor, of Littleton, N. H. Summing up the results of the survey, I would say that we found it possible, by going a little over four miles along the base road running from Fabyans to near the foot of the cogwheel railroad up Mt. Washington, and thence following a side line into the woods toward the foot of Mt. Clinton, to obtain a very large supply of pure mountain-brook water. This plan I recommended to the company, but for certain reasons, among which I mention only the requirements of right of way, it was not possible for the company to adopt at that time the gravity system, which would have secured for both hotels an ample supply. I therefore received orders to provide plans and specifications for a driven-well system.

After the preparation of plans and specifications for wells, pumps, and tanks, a contract was let to the Smith & Thayer Co., of Boston, Mass., on December 19, 1901, for a water-supply plant comprising a battery of twelve 5-inch driven wells (this was afterwards increased to seventeen); three large wooden storage tanks of a combined capacity of 150 000 gallons; a pumping station with one house and one fire pump, the former of 350, the latter of 830, gallons per minute capacity, both of them operated electrically and both made by the Knowles Steam Pump Works; also for pipe lines, gate valves, and hydrants between the tanks and the pumping station, and between the latter and the hotel.

Subsequently, all objections to a gravity line having been removed, I was directed to make plans and specifications for a gravity line, and a second contract was let, also to the Smith & Thayer Co., on March 3, 1902, for a gravity supply line from Clinton Brook.

The two hotels were thus supplied by a double system of water

supply, so that in case of a break in the gravity line or a failure in the supply from the brook, the hotels could be supplied from the wells and the pumping station. Ordinarily, however, the gravity supply was intended to, and did, fulfil all requirements. As subsequent facts proved, it was lucky for the company that both supplies were provided, for about four weeks ago, during the unusual drought, and while forest fires were raging, the Clinton Brook supply became entirely exhausted for the first time in many years, and recourse had to be taken to the pumps. So much as to the history of this water-supply plant.

Mr. Taylor states, on page 135* of the JOURNAL, that he had a contract to procure a gravity system for the hotel by going up Mt. Washington. If so, it was as a sub-contractor for pipe laying; for, as stated above, the plans for this system were prepared in my office and the contract was let to the Smith & Thayer Co.; Mr. Taylor was one of the bidders for the work, but failed to secure it. He subsequently appeared on the ground and had charge, for the Smith & Thayer Co., of the pipe-laying, but of the pipe-laying only. The pipes, specials, valves, etc., for the gravity line were bought and furnished by the Smith & Thayer Co., and not by Mr. Taylor.†

With regard to Mr. Taylor's statement, referring to the wells, that "they have continued to experiment with them until they got disgusted, having spent in the neighborhood of \$40 000, and were still pumping nothing but air," the truth of the matter is as follows:

The seventeen wells were driven by experienced well drivers by means of 8-inch casings, and when the proper depth of from 30 to 40 feet was reached (a few wells are 27 feet deep), the 5-inch well pipe proper was inserted and the 8-inch casing withdrawn. The 5-inch wells were all connected to a suction line of galvanized iron, with very heavy special galvanized iron flanged fittings, put together with gaskets and bolts in the very best manner. The suction pipe was 5, 6, 8, and 10 inches in diameter and was tested and shown to be tight before the same was covered up. The aggregate yield of the wells was 1 050 gallons per minute. This part of the work was completed in the early part of the summer of 1902, and the two pumps referred to were also set, but it was not

* Vol. 17.

† This was the information given me by Mr. Smith, of the Smith & Thayer Co.

possible to get the electric current to run these pumps before the fall of the year. Meanwhile, the gravity supply line furnished an abundance of water, and other pressing work prevented the early completion of the electric conduits for the power to run the pumps. It was some time in September when the current was first turned on, and the pumps pumped water fairly well, — so much so that the contractors expressed themselves as satisfied with the pumps. The writer happened not to be present when these pumps were first started, and naturally he insisted upon a proper test of the pumps before acceptance of the same. When this test was made, late in September, a representative from the contractors, and also Mr. DeLaval, the Superintendent of the Knowles Steam Pump Works, were present, and at that time the pumps gave some trouble, caused by air getting into the suction line and into the pumps. Unfortunately, the season in the White Mountains closes early, and in the first week of October it was necessary to shut down the pumps and drain them on account of freezing weather, and not until the spring of 1903 were the pumps started again. It is not true that the company spent \$40 000 on the wells and pumps, for the cost of the seventeen wells was about \$8 560, and the cost of the two pumps about \$8 600; therefore the entire expenditure for the pump and well plant was about \$17 150.

The statement that the engineer in charge of the work was at a loss to know what to do about it is also incorrect. At the time when the pumps were shut down, he was not quite sure whether there was any possible leak in the wells or in the suction line. The two pumps operated satisfactorily from a mechanical point of view, and were accepted last year. In fact, the entire contract of the Smith & Thayer Co. was accepted and settled except a few extra items of no interest to this discussion.

As to the use of a vacuum pump, this was suggested by Mr. DeLaval, of the Knowles Steam Pump Works. The writer requested him to give an estimate of cost, but this came up to almost \$2 000 and was held in abeyance as probably unnecessary.

Early in the spring of 1903 the writer went to Mt. Pleasant, after all preparations had been made to start the pumps by packing the same and turning on the electric dynamos. *Nothing had*

been done since the previous fall to either the pumps or the wells. When the current was first turned on and the pumps set in motion, to the great satisfaction of all present the pumps discharged their full capacity of water from the series of driven wells. During this test of the pumps two or three bad leaks were found at the well caps of the wells, but these were promptly tightened up, and no further leaks have been discovered since.

I quote from a report received on June 19, 1903, about the operation of the larger or fire pump, which report was written by Mr. Anson S. Rice, the resident engineer in charge of the power plant and of these pumps, as follows:

"I gave the wells a very good test. I ran the big fire pump on them for one and one-half hours and the discharge did not seem to vary any with 15 inches vacuum on the gage. After pumping I measured the water in the wells, and in Wells No. 1 and 13 the water was 1 foot lower than it had stood at a former measurement taken two weeks before; in the rest of the wells the water was 6 inches lower, with the exception of Wells No. 15, 16, and 18, in which the water level was only lowered 2 inches."

Certainly this is a most satisfactory showing.

So far, my only explanation of the failure of the pumps and wells to perform the duty at the one trial made on a certain day in the fall of 1902 is that the water level in the underground basin in which the wells are driven may have been unusually low at that season of the year, while in the spring of this year there seems to have been an abundance of underground water, which is fed from the snow and ice on the peaks and in the ravines of some of the mountains belonging to the Presidential Range. There may also have been some air leaks in the suction line which have since rusted up, and a few air leaks in the well caps which, as stated above, we did find and tightened.

I wish to say that I have no doubt that even now there is some air delivered with the water by the pumps from the wells, for, as Mr. Bowers has well described it, there is always more or less of this difficulty with any driven-well system, but inasmuch as the pumps discharged at the rated capacity it has not been found necessary at this writing to put in the rather expensive and some-

what complicated automatic vacuum pump which was suggested to relieve the trouble.

DISCUSSION.

MR. CHARLES N. TAYLOR (by letter, July 25, 1904). Referring to the article written by Mr. William Paul Gerhard, entitled "A Correction," I find that in order to defend myself I must question some of the statements which he has made. I stated in the discussion referred to by Mr. Gerhard that I had the contract for laying the pipes, setting the hydrants, etc., for supplying water to the new Mt. Washington Hotel, and I would refer any one questioning this to the Donaldson Iron Company, from whom I bought the pipe; the Norwood Engineering Company, who furnished me with the hydrants; and the Ludlow Valve Company, who furnished me with the valves. My contract was with the Smith & Thayer Company, who had the contract for the entire work and sub-let to me the pipe work.

Mr. Gerhard questions my statement in regard to the experiments with the wells and the cost of the plant, but he admits that the "pumps gave some trouble, caused by air getting into the suction line and into the pumps." He also admits that they did not succeed in pumping any water from the driven wells until the next spring. I might add right here, one reason why they could not pump water, in my opinion, was that the wells were of different depths, and that to my knowledge one dry well was connected to the system, and other wells were connected which would yield only a very few gallons of water. This would account for the test being satisfactory in the spring when the ground water was up to nearly the surface of the ground.

In the discussion referred to by Mr. Gerhard, I was seeking information as to the advisability of connecting wells which yielded a small amount of water with better wells, and it was far from my intention to question Mr. Gerhard's work, and that is the reason I did not mention his name. In regard to the misstatement which Mr. Gerhard claims I made as to the cost of the pumping plant, I will say that he has omitted in his estimate the cost of the pipe mains, for which Smith & Thayer paid me nearly \$20 000; he has also omitted the cost of the three wooden

tanks, which I should judge cost between \$3 000 and \$4 000. The above items added to the cost of the wells and the pumps, as given by Mr. Gerhard, makes a total of practically \$40 000, as stated by me in the above-mentioned discussion. The cost of the gravity pipe line was over \$20 000, and is not included in the above.

EXTRACTS FROM A "REPORT RELATIVE TO SUPPLYING THE CITY OF NEW YORK WITH PURE AND WHOLESOME WATER, NOVEMBER, 1833."

COMPILED BY JAMES M. BETTON.

[Read February 10, 1904.]

The following extracts are taken from a "Report of the Commissioners under an act of the Legislature of this State, passed February 26th, 1833, relative to supplying the City of New York with Pure and Wholesome Water," — the report being printed by Peter Van Pelt, Frankfort Street, 1833, and dated November, 1833.

The report was referred to the Committee on Fire and Water, with directions to have five hundred copies printed, including sundry maps and profiles.

Canvas White and David B. Douglass, Esquires, civil engineers, were engaged to make separate and distinct examinations of the Croton, Sawmill, and Bronx rivers in the counties of Westchester and Putnam, together with their several tributaries, and to furnish the commissioners with a map and profile of the country, and their opinion of the quality of the water, the supply that might be depended on in all seasons, and the practicability of conveying it to the city at an elevation of sufficient height that would preclude the use of machinery, and answer all the purposes contemplated.

The engineers were also instructed to designate the best and most feasible route for conducting the water, the most fit and proper manner for constructing the conduits and reservoirs, the probable amount of damage that might be sustained by the proprietors of the water to be taken, and of the land it might be necessary to occupy in constructing the required conduits and reservoirs, together with the total amount of the cost to the city for completing and putting into operation the whole project.

Canvas White was prevented from reporting because of previous engagements on the Raritan and Delaware Canal, and on account of frequent and heavy rains during the summer, flooding the works, but Mr. Douglass submitted a full and ample report, which is given in detail with numerous profiles and sections.

Two routes were proposed for bringing the waters of the Croton and its tributaries: The Inland or Sawmill River Route and the Hudson River Route, the former at an estimated expense of \$5 827 237 and the latter at \$4 718 197, each terminating in a reservoir at Thirty-eighth Street and Fifth Avenue, to contain between fifty and sixty millions of gallons, the water level being 117 feet above the tide.

It was estimated that the population when the work would be completed would not be less than 300 000, and the supply per capita was based upon various investigations made by the commissioners, who learned that the London water companies furnished 162 gallons for each house per diem, or 27 gallons to each inhabitant, counting six persons to each house. The city of Philadelphia, in 1832, supplied 13 806 houses, factories, etc., with 2 000 000 gallons per day, equal to 146 gallons to each establishment, or about 24 gallons to each inhabitant, allowing six persons to a house; Edinburgh and Leith distributed about 15 gallons to each inhabitant, 130 000 persons requiring 1 950 000 gallons every 24 hours, but could increase their supply to 2 661 120 gallons per day, or $20\frac{1}{2}$ gallons per capita.

From these observations the commissioners adopted 22 gallons per diem for each inhabitant of the city of New York, making it necessary to supply 6 600 000 gallons per day. It appears that the Manhattan Company had at that time twenty-five miles of pipes laid in the city, obtaining their supply from a well on Reed Street, the water from which is described as "disagreeable and unwholesome," and had offered to dispose of their works to the corporation, which had also about ten and a half miles of pipes, extending from their reservoir in Thirteenth Street.

The Manhattan Company was organized with a charter drafted by Aaron Burr, allowing them banking privileges, of which they have fully availed themselves, existing to-day as the second oldest bank in New York, and preserving on their premises a tank of

considerable size, constantly filled with water, as a connection with their original charter.

Water obtained from wells was not good in the thickly settled parts of the city, and had changed within the recollection of hundreds, and the commissioners concluded that a similar change might be expected in the northern portion of the city when that became built up also.

Attempts had been made to obtain water by boring, and a certain Mr. Levi Disbrow, who held a patent on improved instruments for penetrating or boring rock, had operated in twenty-three different sections of the city, and in but few instances had succeeded in producing good water. In seventeen cases he stopped at or before reaching rock, and penetrated the earth from 60 to 130 feet, and in six cases he penetrated the rock from 120 to 500 feet, his most successful operation being a deep boring for the Manhattan Company, corner of Broadway and Bleecker Street, 7 inches in diameter, 442 feet in depth, meeting rock at 42 feet, the water proving soft and wholesome, capacity 126 000 gallons in twenty-four hours.

Mr. Disbrow also sunk a well for the corporation at Thirteenth Street. This was 17 feet in diameter and 113 feet in depth, with three horizontal excavations of 4 feet in width and 6 feet in height, extending from the bottom of the well in the rock, two of them 75 feet and one 110 feet in length. This well produced 21 000 gallons in twenty-four hours, but the water was hard, strongly impregnated with some mineral substance, and unfit for drink or cooking, but before the horizontal openings were made the commissioners were assured the water was as pure and soft as that which descends from the clouds. This well, although very useful, was very expensive, costing, including the land, \$57 972.38.

The commissioners estimate the present population at about 250 000, and as a large portion of the Twelfth Ward is under cultivation and will not require an immediate supply, deduct 12 000 as the probable population, leaving the population of the 14 lower wards at 238 000, or about 17 000 in each ward, and, allowing 22 gallons for each person, estimate the daily consumption of each ward as 374 000 gallons, and that 3 wells, similar to that of the Manhattan Company on Bleecker Street, in each

ward, or 42 in all, with their steam engines in constant operation will be required to supply the city.

They estimate that these 42 wells, including the land, engine, reservoir, etc., will amount to \$2 518 825, and submit the following estimate of the annual expense of working an engine of 12 horse-power, night and day:

42 bushels of coal per day, at 21 cents, for 365 days	\$3 219.30
2 engineers and 2 assistants, at \$6.00 per day	2 190.00
Oil, tallow, etc., at 14 cents per day.	51.10
Wear and tear of machinery, at 30 cents per day	109.50
Annual expense per engine	<u>\$5 569.90</u>

The annual expense of 42 engines would be	\$233 935.00
Add the interest on the capital at 5 per cent.	<u>125 941.00</u>
Total annual expense for raising water from wells	\$359 876.00

The commissioners wisely doubt whether a sufficient and wholesome supply could be obtained by boring, and note that a strong objection will arise from placing 42 steam engines in the densely settled parts of the city, to annoy and disturb a neighborhood with the unceasing noise and clatter of the machinery, the constant smoke of the furnaces, and the incessant discharge of steam, thus depreciating the value of property and driving from their vicinity every citizen whose means would permit him to seek for more peaceful and comfortable quarters, and taking also into consideration that the cost of bringing in the Croton water being assumed at \$5 000 000, the interest on which is \$250 000 or \$109 876 less than it would cost to raise the water by machinery, conclude that the corporation must look outside of its own limits for an adequate water supply.

The commissioners note that the subject of supplying the city of New York with water is by no means a new project or of recent date, for as early as 1774, with a population not exceeding 22 000, works were commenced on the high ground to the northwest of the Collect Pond (which at the time of their report, in 1833, had been filled up and converted into building lots), under the directions of Christopher Collis, engineer, who constructed a spacious reservoir on the east line of Broadway, between Pearl and White streets, and sunk a well of large dimensions in the

vicinity of the Collect, a paper money amounting to £2 500, denominated water-works money, and bonds to the amount of £8 850 more, defraying the expenses thereof. This work was abandoned in an unfinished state in 1775, upon the occupation of the city by the British troops incidental to the Revolution.

In 1798 a committee of the council reported that a supply might be obtained from the River Bronx.

In 1799 the Common Council employed William Weston, civil engineer, to examine the River Bronx and report with plans and estimates, and in March of that year Mr. Weston made his report and seems to have held the opinion that the Bronx would give a supply but did not gage the river, further than to calculate the quantity contained in the Rye Ponds, its principal source; and no estimate of expense was furnished.

Nothing further was apparently done until 1822, owing probably to the incorporation of the Manhattan Company, April 2, 1799, who contented themselves by erecting works at Chambers and Reed streets and did not look for a foreign supply, the water they furnished being stated to contain by analysis 125 grains of foreign matter in the gallon.

In this year, 1822, a committee appointed by the mayor reported an examination of the Bronx and its lakes, and appointed Canvas White, Esquire, civil engineer, who did not report until 1824.

Mr. White proposed, by raising a dam of six feet at the upper Rye Pond and lowering the outlet, to obtain 6 600 000 gallons per day, or 3 600 000 more than the natural flow of the river in the driest season, estimating the cost of bringing the water to a reservoir near the park as \$1 949 542.

Nothing came of this, and, in 1825, the New York Water Works Company was incorporated, Canvas White, Esquire, being the engineer, and it was proposed to take its supply from the Bronx, it being estimated that 9 100 000 gallons could be delivered daily at a total expense of \$1 450 000. The charter of this company proved defective, and, after legal complications incidental to an amendment thereof, the company was dissolved in 1827.

In 1831 the Board of Aldermen reported in favor of applying to the legislature for an act allowing the raising of money by loan

for the purpose of introducing a supply of pure water to the city, but this did not pass into a law.

In 1832 DeWitt Clinton, Esquire, civil engineer, was employed by the Common Council to examine the Croton River and report the best plan of crossing the Harlem River; he reported, in December of that year, in favor of an open aqueduct following the line of the Croton and Hudson rivers and crossing the Harlem River on an arch 138 feet high and 1 000 feet in length, estimating the total cost at \$2 500 000.

In 1833 the Common Council petitioned for an act, under the authority of which this report was made, this becoming a law of the state of New York, February 26, 1833.

This report is fully illustrated by maps and profiles, and is signed by Stephen Allen, Saul Alley, William W. Fox, Chas. Dusenberry, and Benjamin M. Brown, commissioners.

Supplementary to this report follows an address of John L. Sullivan, civil engineer, a co-patentee with Levi Disbrow in 1833, demonstrating the advantages of a rock water company with banking privileges, and also a proposition to the Manhattan Company to fill their aqueduct with rock water, an opportunity being afforded to such as were disposed to subscribe to the stock thereof, a capital of \$2 000 000 being named, one half of which was to be appropriated to the water works and the other million to a banking capital.

The petitioners begin their address by respectfully representing "that being patentees and proprietors of those instruments by which the discovery of the deep seated pure water beneath this city was made, and by which alone it is accessible"—evidently having a stronger and firmer belief in the validity of the current Letters Patent than has been experienced and demonstrated by later generations. They desired to lay down pipes in any usual manner through the streets, to deliver water into the houses of those disposed to take it, on terms that should not exceed the average of the water rates at Boston and Philadelphia.

It was not proposed to make costly wells in the deep sands of the city, but rather to avoid such, utilizing the iron tube with a flat socket joint devised for this work, the estimate for each boring being,—

Lot	\$2 000.00
Boring, pump, and engine	5 000.00
Buildings and cistern.	3 000.00
Total	<u>\$10 000.00</u>

sufficient to, probably, raise 130 000 gallons in twenty-four hours, if constantly in operation, which, at 40 gallons each, was considered sufficient for 3 000 families. The utmost annual expense was estimated as:

Two men	\$730.00
Fuel, 187 tons anthracite, at \$8.00	1 496.00
Oil and repairs, 10 per cent.	222.00
Deterioration of machinery, 10 per cent.	222.00
or	<u>\$2 670.00</u> each well.

Thirty-one of these stations were proposed, and, as an instance of the economy, the expense of one horse-power is stated as ten pounds of coal per hour, or sixteen tons per year, costing at \$6.00 per ton, \$96.00; and it was further suggested that the surplus power from each engine could be devoted to some mechanical work in exchange for the necessary attention, thus saving the item of attendance and perhaps some part of the fuel.

Incidentally, it is mentioned that some of the most frequented hotels in New York pay (it is stated) for rock water brought in casks about \$400 a year, and that one boring near the park might supply all the principal hotels and all have pure baths.

The probability of conflicting with the existing Manhattan Company is discussed and the point advanced that there is room and occasion for two companies, and the danger of trusting to a natural water supply, owing to the extraordinary evaporation in this, the driest climate known, is advanced, and the practical John L. Sullivan supplements his paper with a "Notice of an invention called a Steam Camel for lifting a vessel over a shoal."

In a further report, February 16, 1835, the water commissioners mention having recommended, November 12, 1833, the Croton River as the only pure source of supply, and pass to a consideration of all matters relative to supplying the city with pure and wholesome water, among them being a plan to convey either six or sixteen million gallons from the mouth of the Croton and at an elevation of one hundred and twenty-five feet above low water

at New York and deliver same to the same height by means of iron pipes, which plan was shelved on account of engineering discrepancies.

They refer to Loammi Baldwin's report on the subject of introducing pure and wholesome water into the city of Boston, the number of wells in that city being 2 767, of which 682 were unfit for use, 7 city wells only yielded soft water and 33 were deep borings, only 2 of which furnished soft water.

A discussion follows of the plan of Bradford Seymour, of Utica, dated November 21, 1834, involving the erection of a permanent dam across the Hudson River at or near the site of the old State Prison, at the foot of Amos Street, to raise the surface of the water from 18 to 24 inches above high tide, the expense being estimated by Mr. Seymour at \$1 250 000, and for the construction of as many ship locks as may be proper, \$140 000 each, \$100 000 to \$200 000 more being considered as necessary if a lock in the center of channel is provided.

The advantages, briefly stated, are the purity of the waters; the formation of a hydraulic power of 30 000 horses, 27 000 of which may be employed for manufacturing and 3 000 for elevating the water to reservoir; all bars or "overslaughts" above the dam will be removed by the down current; a safe connection from the city to Albany on the ice for three months in the year furnished; the danger from freshets overcome; and the advantage of solid and pure ice at small expense gained.

The commissioners did not deem it their duty to incur any engineering expense in the examination of this scheme, stating they considered that in locking vessels through the dam large quantities of salt water would be admitted, unfitting the supply for domestic use at least; that the consent of the state of New Jersey would have to be obtained, as well as that of the United States; that the number of vessels passing would cause the dam to be considered a hindrance to navigation; that they could find no data in the office of the street commissioners from which to estimate the difficulties to be encountered in building the dam; that the raising of the water would cause damage to low-lying lands; that the closing of the river by ice for three months in the year would cause more injury to navigation than the privilege

of proceeding to Albany on the ice, or of procuring a supply of that article would produce benefits. They also considered the damage incidental to the destruction of the shad fishery, and conclude, upon the opinion of Frederick Graff, superintendent Fair Mount Water Works, that a head of twenty-four inches will not answer the purpose intended, owing to the short space of time the wheels would work, and to raise the level higher would destroy so much land that the damage claims furnish a reason for abandoning the project, let alone the injury to the navigation of the river, besides the cost, estimated by Mr. Graff at about four millions.

Mr. Graff, while thinking that if a bridge could be built across the Hudson, without injury to the trade of this great river, a supply of water might be obtained from the Passaic Falls, concludes that the only safe resource to be relied on is the Croton.

At that day the highest building, that of the new university, was 108 feet above tide water, and the surface of the proposed reservoir was to be 114 to 116 feet above the same base.

In discussing the question of revenue the following facts appear: The Manhattan Company apportion their charge in accordance with the number of fireplaces in the dwellings supplied, small houses containing from one to three fireplaces paying \$5.00 per annum, while houses of the largest class pay \$15.00, the average of the charge for dwellings being \$9.63, if occupied by one family, \$3.00 being added for each additional family; grocery stores pay \$10.00 and bake houses \$10.00 for each oven, larger consumers by agreement, the laying and repairing of the lateral pipes being done at the expense of those receiving the water. As a comparison, in Boston, one thousand families were supplied with water by the Boston Aqueduct Company at an annual charge of from \$10.00 to \$12.00 each family; in Providence the charge was \$10.00 per annum for a family of six persons, and in Albany twelve hundred dwelling houses were supplied at rates varying from \$6.00 to \$16.00. In London the general average was about \$8.00, 21 steam engines of 1340 horse-power being employed to raise the water. In Philadelphia a family of six persons paid only \$5.00 per annum.

The estimated revenue from the proposed works in New York

City was \$310 516, based on 20 000 water takers at \$8.00 each. Among these 20 000 houses, 2 000 baths were estimated. There were 60 steam engines in the city used for mechanical purposes, which consumed about 45 000 gallons per day, for which a rate of about \$35.00 was proposed.

Closing the volume is a report of Peter Cooper and other special commissioners, December 22, 1840, regarding the powers and duties of the water commissioners, and investigating certain complaints as to the commissioners having paid too high prices for materials and labor, from which it appears that lead cost five cents per pound, repairing the streets, twenty-five cents per square yard, labor an average of \$1.08 to \$1.09 per day, including foremen — \$1.25 being considered wasteful.

The item of stopcocks is discussed at some length, it being shown that in one case, in 1835, in making a connection at the corner of the Bowery and Grand Street, all of the stopcocks up to the reservoir at Thirteenth Street, the number not stated, failed to shut off the water, which had finally to be shut off at the reservoir, and three days (one of them a Sunday!) pumping with a fire engine was required to free the trench; and in 1839 twenty-three stopcocks of the old kind had to be closed to shut the water off at one point. The commissioners decided to change the pattern.

The comparative merits of casting iron pipe direct at the blast furnace from the first melting of the ore and from remelted pig iron in a cupola furnace are discussed, and it is noted that the prices paid for 12-inch pipe varied from \$1.60 to \$1.90 per foot, with weights running from 580 to 760 pounds.

A complaint was made that 12-inch pipes were laid in certain streets in place of 6-inch, and it was answered that the department had used up all of the 6-inch pipe; and it is to be presumed that the pipe foundries' agents were not as plentiful or keen as at the present day, or that shipments were delayed.

CONTRACT AND SPECIFICATIONS FOR FURNISHING CAST-IRON WATER PIPES AND SPECIAL CASTINGS.*

NEW BEDFORD WATER WORKS.

CITY OF NEW BEDFORD, MASS.

....., 19..

TO IRON FOUNDERS.

Proposals for Coated Cast-Iron Water Pipes
and Special Castings.

INFORMATION FOR BIDDERS.

Sealed bids or proposals addressed to the New Bedford Water Board, and indorsed "Proposals for Furnishing Cast-Iron Water Pipes and Special Castings," will be received at the office of the Board, City Hall, until.....o'clock of theday of19..

All bids must be made upon the blank form of proposal annexed hereto, and should give the price for each item of the work proposed, both *in writing* and *in figures*, and be signed by the bidder, with his business address and place of residence.

All proposals containing bids not called for in this advertisement will be considered informal.

Each bid must be accompanied by a properly certified check for dollars (\$:.....), payable to the City of New Bedford; said check to be returned to the bidder unless forfeited under the condition herein stipulated.

The amount and character of the securities for the fulfillment of the contract will be determined by the New Bedford Water Board after the proposals are opened.

If a bond is required with the contract, the sureties thereon

* Since the adoption of the Standard Specifications for Cast-Iron Pipes and Special Castings, there have been several inquiries for a form of contract for use with the standard specifications. This form shows how the requirement has been met by the New Bedford Water Works. — Editor.

must be residents of Massachusetts, or a reliable surety company authorized to do business in Massachusetts, and satisfactory to the Water Board.

The party to whom the contract is awarded will be required to present forthwith to the Board the names of the sureties to be offered, and to execute the contract and furnish the bond, duly executed, with satisfactory sureties, within six days (not including Sunday) from the date of the mailing of a notice from the Board to the bidder, according to the address given by him, that the contract is ready for signature, and, in case of his failure or neglect so to do, the Board may at its option determine that the bidder has abandoned the contract, and thereupon the proposal and acceptance shall be null and void, and the check accompanying the proposal shall be forfeited to the City of New Bedford.

All bids will be compared on the basis of the following estimate of quantities to be furnished:

Item.....	tons.....	inch pipe, Class.....
Item.....	tons.....	inch pipe, Class.....
Item.....	tons.....	inch pipe, Class.....
Item.....	tons.....	inch pipe, Class.....
Item.....	tons.....	inch pipe, Class.....
Item.....	tons.....	inch pipe, Class.....
Item.....	tons.....	inch pipe, Class.....
Item.....	tons.....	inch pipe, Class.....
Item.....	tons of special castings.....	

These quantities are considered as approximate, and the Board, therefore, expressly reserves the right of increasing or diminishing the same as in their opinion may be necessary, not exceeding twenty per cent. of the amount of straight pipes and special castings.

The Board also expressly reserves the right to reject any or all bids, should they deem it for the interests of the City of New Bedford so to do.

.....

NEW BEDFORD WATER BOARD.

Superintendent.

Item—For all.....inch straight pipe, Class.....
the sum of.....

.....(\$.....) per ton of 2 000 lbs.

Item—For all special castings, the sum of.....

.....(\$.....) per ton of 2 000 lbs.

If this proposal shall be accepted by the New Bedford Water Board, and the undersigned shall fail to contract as aforesaid, and, if required, should fail to provide a bond of such amount and character satisfactory to the Board, within six days (not including Sundays) from the date of the mailing of a notice from the Board to him, according to the address herewith given, that the contract is ready for signature, then the Board may, at its option, determine that the bidder has abandoned the contract, and thereupon the proposal and acceptance shall be null and void, and the certified check for.....dollars (\$.....) accompanying this proposal shall become the property of the City of New Bedford, otherwise, the accompanying check shall be returned to undersigned:

Signature of Bidder, with Residence and Business Address:

.....
.....
.....
.....
.....

Date,

The names and residences of all persons and parties interested in the foregoing bid, as principals, are as follows:

Notice.— Give first and last name in full, and in case of corporations give name of President, Treasurer, and Manager:

.....
.....
.....
.....
.....
.....

NEW BEDFORD WATER WORKS.

NEW BEDFORD.

CONTRACT AND SPECIFICATIONS FOR FURNISHING COATED CAST-
IRON WATER PIPES AND SPECIAL CASTINGS.

THIS AGREEMENT, made and concluded this
day of, in the year one thousand nine hundred
and, between the City of New Bedford by the
New Bedford Water Board, of the first part, and
.
of
in the State of, part of the
second part:

A. WITNESSETH, That the said Contractor has agreed, and by these presents does agree, with the said City for the consideration hereinafter mentioned, at his own proper cost and expense, to do all the work and furnish all the materials called for by this agreement, in the manner and under the conditions hereinafter specified.

B. To prevent all disputes and litigation, it is further agreed by and between the parties to this contract, that the Superintendent (meaning thereby the individual at any time holding the position or acting in the capacity of Superintendent of the New Bedford Water Board) shall be referee in all cases, to determine the amount or the quantity of the several kinds of pipes and special castings which is to be paid for under this contract, and to decide all questions which may arise relative to the fulfillment of this contract on the part of the Contractor; and his estimates and decisions shall be final and conclusive; also, that said Superintendent, by himself, or by assistants, and inspectors acting for him, shall inspect the materials to be furnished and the work to be done under this agreement, to see that the same strictly correspond with those stipulated in the specifications hereinafter set forth.

C. The parties hereto further agree that wherever in this contract the words defined below are used, they shall be understood to have the meanings herein given:

The term "Water Board" shall mean the New Bedford Water Board, or any Board or Committee duly authorized to represent the City of New Bedford in the execution of the work covered by this contract.

The words "Superintendent" or "Engineer," when not further qualified, shall mean the Superintendent of the New Bedford Water Board, or his or their properly authorized agents, limited by the particular duties intrusted to them.

The word "Contractor" shall mean the person or persons, co-partnership or corporation, who have entered into this contract as party of the second part, or his or their legal representatives.

SPECIFICATIONS.

D (1) The work to be done consists in furnishing, sound and complete in all respects, and in strict conformity with all the conditions and requirements of this contract and these specifications, the following cast-iron pipes and special castings:

.....tons of.....	inch straight pipe, Class.....
.....tons of.....	inch straight pipe, Class.....
.....tons of.....	inch straight pipe, Class.....
.....tons of.....	inch straight pipe, Class.....
.....tons of.....	inch straight pipe, Class.....
.....tons of.....	inch straight pipe, Class.....
.....tons of.....	inch straight pipe, Class.....
.....tons of.....	inch straight pipe, Class.....

.....tons of special castings, more or less, as may be required in connection with the above-described pipe, consisting of branches, bends, reducers, caps, curved pipe, sleeves, and all or any other special castings directed by the Superintendent in this connection, subject to all the conditions and requirements of this contract and specifications.

The amounts in tons of the various diameters and classes of pipes above called for are to be considered as approximate only. The Superintendent shall have the right of increasing or diminishing the amounts called for by this contract in any way, and for any reason which he may deem necessary, provided such increase or diminution does not exceed twenty per cent. of the total amount of the contract.

Where Delivered.

(2) All pipes and other castings shall be delivered
.....
.....

(3) All castings are to be made in strict accordance with the Standard Specifications for Cast-Iron Pipe and Special Castings adopted by the New England Water Works Association, September 10, 1902. A copy of these specifications is hereto annexed, and forms a part of this contract.

Marking.

(4) In addition to the provision of Section 6, Standard Specifications for Cast-Iron Pipe and Special Castings adopted by the New England Water Works Association, September 10, 1902, each pipe and special casting shall have cast upon it the letters N. B. W. W.

How Delivered.

(5) The delivery of all pipe and special castings shall be completed on the.....day of.....
.....

Superintendent to Explain Specifications.

(6) All the work contemplated and described in this contract and specifications shall be done to the satisfaction of the Superintendent, who shall be sole judge as to the fitness of materials, and shall have the right of correcting any errors or omissions in the contract and specifications when such correction is necessary for the proper fulfillment of their intention; the action of such correction to date from the time that the Superintendent gives due notice thereof in writing.

F. On condition of the true and faithful performance of this agreement and these specifications, the said City of New Bedford agrees to pay to the said Contractor at the rate of
.....
for all.....inch straight pipe, Class....., per
ton of 2 000 lbs.,.....

.....	for all.....inch straight pipe, Class....., per
.....	ton of 2 000 lbs.,.....
.....	for all.....inch straight pipe, Class....., per
.....	ton of 2 000 lbs.,.....
.....	for all.....inch straight pipe, Class....., per
.....	ton of 2 000 lbs.,.....
.....	for all.....inch straight pipe, Class....., per
.....	ton of 2 000 lbs.,.....
.....	for all.....inch straight pipe, Class....., per
.....	ton of 2 000 lbs.,.....
.....	for all.....inch straight pipe, Class....., per
.....	ton of 2 000 lbs.,.....
.....	per ton of 2 000 lbs. for the special castings.

The prices per ton above mentioned include the coating of pipes and special castings in accordance with the terms of the specifications herein named, and all labor and expenses attending the inspection, proving, and weighing at the foundry of the pipes and special castings, except the salary of the inspector. If the completion of the contract is delayed beyond the specified time, the expenses of inspection caused by such delay shall be deducted from any amount which may be due the Contractor, unless otherwise decided by the Superintendent; but this provision shall not affect any right which may accrue to the Board by reason of such delay.

F. Payments to be made on the weight of said castings received in proper order and condition, according to the certificate of the Superintendent, as soon as may be convenient under the City system of monthly audit. Provided, that nothing herein con-

tained be construed to affect the right, hereby reserved, of the said New Bedford Water Board to reject the whole or any portion of the aforesaid pipes and special castings, should the said certificate be found or known to be inconsistent with the terms of this agreement, or otherwise improperly given.

G. In order that the conditions of this contract, as regards the delivery, may not be misunderstood, it is hereby agreed that this contract may, at the option of the said Water Board, be declared and considered forfeited if, upon the day of next the Contractor shall have failed to deliver all the pipe and special castings herein enumerated, the dangers of the sea excepted. And it is mutually agreed between said parties that if said pipe and castings shall not be delivered in accordance with the terms and date herein specified, the check for dollars (\$.....) hereafter referred to, deposited with said Water Board, or such portion thereof as said Water Board shall see fit to retain, shall be forfeited to said City of New Bedford; and it is further agreed that the permitting said Contractor to go on and deliver said pipes and castings, after failure to comply with the terms of delivery herein specified, shall not operate as a waiver of the rights of said Board to retain said check, or any portion thereof.

H. It is further agreed, that if, under the process of inspection, there shall have been rejected, under the conditions of this contract and specifications, during any twenty days continuously of its limitation, twenty-five per cent. of the pipes and special castings offered within that time for acceptance, the contract may, at the option of the said Water Board, be declared forfeited, and it shall be forfeited accordingly.

I. The parties hereto further agree that this contract shall be in writing and executed in duplicate, one of which duplicates shall be kept by the said New Bedford Water Board and one by the Contractor, that this contract or any part thereof or any sum due or to come due thereunder shall not be assigned or transferred without the written consent of said Water Board and shall at the election of said Water Board be utterly void as to the said city, if any person appointed to any office or employed by virtue

of any ordinance of said city, or of any Act of the Legislature relating to the supplying of water to said city, or any matter or thing connected therewith, is either directly or indirectly interested therein.

J. The said Contractor further agrees that, if required, he will execute a bond, with such sureties as shall be approved by said Water Board, conditioned to well and truly keep and perform all the terms and conditions of this contract on his part to be kept and performed, and to indemnify and save harmless the said City of New Bedford, as herein stipulated.

K. The said Contractor further agrees to deposit with said New Bedford Water Board a certified check in the amount of dollars (\$.....).

If the said Contractor shall well and truly keep and perform all the terms and conditions of the contract on his part to be kept and performed, and shall indemnify and save harmless the said City of New Bedford, as herein stipulated; then the above-mentioned check shall be returned to said Contractor; otherwise, said check shall be forfeited to the said City of New Bedford.

L. The said Contractor further agrees that the said Water Board may, if it deem it expedient to do so, retain out of any amounts due to the said Contractor sums sufficient to cover any unpaid claims of mechanics or laborers for work or labor performed under this contract; provided, that notice, in writing, of such claims, signed by the claimants, shall have been previously filed in the office of the City Clerk.

M. The said Contractor further agrees that he will indemnify and save harmless the said city from all suits or actions, of every name and description, brought against the said city for or on account of any injuries or damages received or sustained by any person or persons, by or from the said Contractor, his servants or agents, in the construction of said work, or by or in consequence of any negligence in guarding the same, or any improper materials used in its construction, or by or on account of any act or omission of the said Contractor or his agents; and the said Contractor further agrees that so much of the money due to him under and by virtue of this agreement, as shall be considered necessary by the said Water Board, may be retained by the said city until all such suits

or claims for damages as aforesaid shall have been settled, and evidence to that effect furnished to the satisfaction of the said Water Board.

N. The said Contractor further agrees that if the work to be done under this agreement shall be abandoned, or if this contract shall be assigned by the said Contractor otherwise than as herein specified, or if the conditions as to rate of progress are not fulfilled, or if at any time the Superintendent shall be of opinion, and shall so certify, in writing, to the said Water Board, that said work, or any part thereof, is unnecessarily or unreasonably delayed, or that the said Contractor is wilfully violating any of the conditions or covenants of this contract, or is fulfilling said contract in bad faith, the said Water Board shall have the power to notify the said Contractor to discontinue all work, or any part thereof, under this contract; and thereupon the said Contractor shall cease to continue said work, or such part thereof as the said Water Board may designate, and the said Water Board shall thereupon have the right to procure of other parties all or any part of the work left uncompleted by the said Contractor, and the said Contractor shall be liable in any damages caused the City of New Bedford by reason of said Contractor not completing this agreement.

O. The said Contractor further agrees that all pipes and special castings, of whatsoever description, upon which advances may have been made, shall become thereby, so far as acceptable in other respects, the exclusive property of the said city; and whatever may be found, after delivery, objectionable in castings upon which advances may have been made, the said Contractor shall make good and replace immediately on receiving notice thereof; and if said defective or objectionable castings are not replaced within thirty days after the delivery of said notice to the said Contractor at his office or place of business, the said New Bedford Water Board, as agent of the party of the first part, may then obtain from other parties, at their discretion, the castings rejected in the terms of this agreement, and the cost and expense of replacing such rejected castings by sound and unobjectionable ones shall be paid by the said Contractor or deducted from any balance due or which may become due to the said Contractor by the said city.

P. And it is also to be understood and agreed that, in case of any alterations, so much of this agreement as is not necessarily affected by such alterations shall remain in force upon the parties hereto.

Q. And it is further agreed that no payment for work done under any alteration of this contract, as aforesaid, shall be made until the completion of the whole contract.

R. And the said Contractor hereby further agrees that the payment of the final amount due under this contract, and the adjustment and payment of the bill rendered for work done in accordance with any alterations of the same, shall release the city from any and all claims or liability on account of work performed under said contract, or any alteration thereof.

S. This is to bind the representatives of the parties respectively.

IN WITNESS WHEREOF, the parties to these presents have hereunto set their hands the day and year first above written.

The City of	{	.....
New Bedford		<i>President.</i>
by the		.....
New Bedford		.....
Water Board		.....

.....

.....

.....

.....

Signed in the presence of

.....

.....

KNOW ALL MEN BY THESE PRESENTS, That we,.....

....., as principal

.....

.....

..... as suret

are held and firmly bound unto THE CITY OF NEW BEDFORD, in

the sum of.....dollars,
lawful money of the United States of America, to be paid to the
said CITY OF NEW BEDFORD, or its certain Attorney, its suc-
cessors and assigns, for which payment, well and truly to be
made, we bind ourselves, our heirs, executors, and administrators,
jointly and severally, firmly by these presents.

Sealed with our seals, dated the.....
day of.....in the year one
thousand nine hundred and.....
.....

WHEREAS, The said.....
.....ha made a contract with
the City of New Bedford, bearing date the.....
day of.....one thousand nine hundred and
.....for furnishing cast-iron
water pipes and special castings.

NOW, THE CONDITION OF THIS OBLIGATION IS SUCH, That if
the said.....
.....
shall well and truly keep and perform all the agreements, terms,
and conditions of the said contract on.....
part to be kept and performed, and shall indemnify and save
harmless the said CITY OF NEW BEDFORD and said Board,
against, and shall upon demand pay to the said city all damages,
costs, and expenses caused by and in every way growing out of the
failure of said.....
.....to keep and perform all the agree-
ments, terms, and conditions of said contract on.....
part to be kept and performed, then this obligation shall be of no
effect; otherwise, it shall remain in full force and virtue.

.....[SEAL]
.....[SEAL]
.....[SEAL]
.....

Signed and sealed in presence of
.....
.....

WATER WORKS STATISTICS FOR THE YEAR 1903, IN FORM ADOPTED BY THE NEW ENGLAND WATER WORKS ASSOCIATION.

COMPILED BY CHARLES W. SHERMAN, EDITOR, JOURNAL OF THE NEW
ENGLAND WATER WORKS ASSOCIATION.

The following tables contain more or less complete statistics for forty-eight water works, which have used, more or less closely, the form adopted by the Association for summarizing statistics. Some of these works report under very few of the headings of the summary.

The Editor has made no attempt to compile statistics from water-works reports which do not include at least a partial summary.

The report of the Committee on Uniform Statistics, containing the form as endorsed for use in the 1901 reports, is printed on page 51 of Vol. 15 of the JOURNAL (March, 1902). The page for Financial Statistics was changed by vote of the Association in September, 1902, as reported in the December, 1902, JOURNAL (Vol. 16, p. 263). Blank forms for use in preparing summaries are printed by the Association, and will be furnished on request.

Previous compilations of statistics may be found in the JOURNAL, as follows:

<i>Statistics for</i>		<i>Reference to Journal</i>
1886	Vol. I,	No. 4, p. 29
1887	Vol. II,	No. 4, p. 28
1888 to 1892 inclusive ..	Vol. VII,	p. 225
1893	Vol. IX,	p. 127
1894	Vol. X,	p. 131
1895-96	Vol. XII,	p. 273
1897-99	Vol. XV,	p. 65
1900	Vol. XV,	p. 367
1901	Vol. XVI,	p. 223
1902	Vol. XVII,	p. 235

In the various tabulations, statistics are given for the following places and years:

<i>Place</i>	<i>Year</i>
1. Albany, N. Y.	1900
2. Andover, Mass.	1900
3. Arlington, Mass.	1900
4. Atlantic City, N. J.	1898, 1900-03
5. Attleboro, Mass.	1894-1903
6. Bay City, Mich.	1886-87, 1893-96, 1900-03
7. Belmont, Mass.	1902-03
8. Beverly, Mass.	1903
9. Billerica, Mass.	1899-1903
10. Boston, Mass.	1886-94, 1897, 1900, 1903
11. Brockton, Mass.	1893-1903
12. Burlington, Vt.	1886-1903
13. Cambridge, Mass.	1900-03
14. Chelsea, Mass.	1900-03
15. Cleveland, Ohio	1902-03
16. Concord, N. H.	1895, 1898, 1900-03
17. Dover, N. H.	1900
18. Erie, Pa.	1900
19. Essex Junct., Vt.	1900
20. Fall River, Mass.	1886-95, 1897-1903
21. Fitchburg, Mass.	1886-92, 1894-1903
22. Freeport, Me.	1901
23. Geneva, N. Y.	1900
24. Haverhill, Mass.	1900
25. Holyoke, Mass.	1886-92, 1897-98, 1900-03
26. Hull, England	1900
27. Ipswich, Mass.	1900
28. Keene, N. H.	1899-1900, 1903
29. Lawrence, Mass.	1902-03
30. Leicester, Mass.	1900
31. Leominster, Mass.	1900
32. Lewiston, Me.	1900
33. Lowell, Mass.	1886, 1897-1903
34. Lynn, Mass.	1888-98, 1900-03
35. Madison, Wis.	1900, 1902-03
36. Manchester, N. H.	1900
37. Marlborough, Mass.	1900, 1903
38. Maynard, Mass.	1901-03
39. Metropolitan Water Works, Mass.	1900-03
40. Middleboro, Mass.	1895-1903
41. Middletown, Conn.	1902

<i>Place</i>	<i>Year</i>
42. Minneapolis, Minn.	1900-03
43. Nantucket, Mass.	1900
44. Nashua, N. H.	1900
45. New Bedford, Mass.	1886-1903
46. New London, Conn.	1886-1903
47. Newton, Mass.	1888-1903
48. Norwich, Conn.	1901
49. Oberlin, Ohio	1893-1903
50. Plymouth, Mass.	1886-1903
51. Providence, R. I.	1897-1903
52. Quincy, Mass.	1893, 1900-01
53. Reading, Mass.	1893, 1895-1903
54. Reading, Pa.	1901-03
55. Rochester, N. Y.	1903
56. St. John, N. B.	1902-03
57. Salem, Mass.	1900
58. Sandusky, Ohio	1886
59. Schenectady, N. Y.	1886, 1900-01
60. Somerville, Mass.	1900-03
61. Springfield, Mass.	1886-1903
62. Taunton, Mass.	1886-1903
63. Toronto, Canada	1893
64. Trenton, N. J.	1886-87
65. Troy, N. Y.	1886, 1888-93, 1897-99
66. Waltham, Mass.	1886-1903
67. Ware, Mass.	1886, 1888-92, 1900-03
68. Watertown, Mass.	1900
69. Wellesley, Mass.	1888-93, 1898-1903
70. Westerly, R. I.	1902-03
71. Whitman, Mass.	1897-1903
72. Wilmington, Del.	1900
73. Winchendon, Mass.	1900-03
74. Woburn, Mass.	1900-03
75. Woonsocket, R. I.	1886-1900, 1902-03
76. Worcester, Mass.	1900
77. Yonkers, N. Y.	1893-96, 1900-03

1903. — TABLE I. — GENERAL AND PUMPING STATISTICS.

Number	Name of City or Town	Date of Construction of Works.	By Whom Owned	Source of Supply	Mode of Supply	1 Builders of Pumping Machinery	2.—Description of Fuel Used				
							a Kind	b Brand of Coal	c Av. Price per Gross Ton	d Per Cent of Ash	e Wood. Price per Cord
1	Atlantic City, N. J.	1882 } 1888 }	City.	Wells and Absecon Creek.	Pumping.	Worthington, Gordon-Max'll, d'Auria, Smith-Vaile.	Bituminous.	Standard.	\$4 10	6	...
2	Attleboro, Mass.	1873	Town.	Well near Seven Mile River.	Pumping.	Deane, Barr.	Bituminous	Eureka.	...	...	...
3	Bay City, Mich.	1872	City.	Saginaw Bay.	Pumping.	Holly.	Bituminous.	Slack.	2 02	23	\$1 85
4	Belmont, Mass.	1887	Town.	Metropolitan W.W.	Pumping.	...	...	...	...	...	...
5	Beverly, Mass.	1869-70	City.	Wenham Lake and Longham Res.	Pumping.	Holly.	Bituminous.	Cumberland.	5 25	12	...
6	BillERICA, Mass.	1898	Town.	Driven Wells.	Pumping.	Barr.	Bituminous	Georges Creek-New River.	6 02	...	...
7	Boston, Mass.	1848	City.	Metropolitan W.W.	Pumping.	...	...	...	...	...	...
8	Brookton, Mass.	1880	City.	Salisbury Brook.	Pumping.	Worthington, Holly	...	...	...	...	...
9	Burlington, Vt.	1867-8	City.	Lake Champlain.	Pumping.	Worthington.	Bituminous.	Nonpareil.	4 10	...	...
10	Cambridge, Mass.	1855	City.	Hobbs and Stony Brooks, Fresh Pd.	Pumping.	Leavitt, Worthington, Blake.	Bituminous.	Cumberland.	4 20-9 50	...	...
11	Chelsea, Mass.	1867	City.	Metropolitan W.W.	Pumping.	Worthington, Knowles, Allis, Holly, Kilby.	Bituminous	...	...	...	...
12	Cleveland, Ohio.	1856	City.	Lake Erie.	Pumping.	...	Bituminous	Salineville, Slack.	1 51	...	...
13	Concord, N. H.	1872	City.	Penacook Lake.	Gravity and Pumping.	...	...	...	...	...	...
14	Fall River, Mass.	1874	City.	N. Watuppa Lake.	Pumping.	Worthington, Davidson,	Bituminous	Cumberland, Georges Creek.	...	...	...
15	Fitchburg, Mass.	1873	City.	Storage Reserv'r.	Gravity.	...	...	...	...	...	...

1903.—TABLE 1, *Concluded*.—GENERAL AND PUMPING STATISTICS.

Number	Name of City or Town	Date of Construction of Works	By Whom Owned	Source of Supply	Mode of Supply	1 Builders of Pumping Machinery	2—Description of Fuel Used				
							a Kind	b Brand of Coal	c Av. Price per Gross Ton	d Per Cent. of Ash	e Wood Price per Cord
25	Middleboro, Mass.	1885	Fire Dist.	Well near Nemas- ket River.	Pumping.	Deane.	Bituminous	{ Pocahontas, Georges Creek, Pardee.	\$3 85-6 50	..	..
26	Minneapolis, Minn.	1868	City.	Mississippi River.	{ Pumping. { Hardenbergh, Waters, Pray, Strothman, Worthington, Holly.	{ Sawdust, Edgings, etc. (also water power).	..	.....²	..	..
27	New Bedford, Mass.	1866	City.	Quittacas Ponds.	Pumping.	Leavitt.	Bituminous.	Pocahontas.	5 62	7	\$4 00
28	New London, Conn.	1872	City.	{ Lake Kononoe & Barns Reserv'r. }	Gravity and Pumping	..	..	..	..	..	..
29	Newton, Mass.	1876	City.	Collecting gallery near Charles Riv.	Pumping.	Worthington.	{ Bituminous & Anthracite Screenings.	Penna., New River.	5 83	10	6 00
30	Oberlin, Ohio.	1887	Village.	East branch of Vermilion River.	Pumping.	Deane.	Bituminous.	Pocahontas.	4 00	..	..
31	Plymouth, Mass.	1855	Town.	{ Gt. & Little South and Lout Ponds. }	Gravity and Pumping.	Worthington.	Bituminous.	Various.	5 50	..	..
32	Providence, R. I.	1870	City.	Pawtuxet River.	{ Pumping. { Worthington, Corliss, Holly.	{ Bituminous Cumb., Pocah. New River, Egg, Pea, and Buckwheat.	{ Bituminous Anthracite.	{ Georges Creek, Cumb., Pocah. New River, Egg, Pea, and Buckwheat.	{ 5 22 5 59 4 37	{ 10 14 23	{ 4 50 4 50 4 94
33	Reading, Mass.	1890	Town.	Filter gallery.	Pumping.	Blake.	Bituminous.	Carbon, Poca- hontas.	6 33	..	..
34	Reading, Pa.	1819	City.	Creeks & Springs.	Gravity and Pumping.	Worthington.	Bituminous.	..	3 29	14	3 50

35	Rochester, N. Y.	1873 City.	{ Hemlock Lake. Genesee River. ³	Gravity. Pumping.	Holly.	Bituminous.	Pittsburg.	3 70	12	...
36	St. John, N. B. East Side. West Side.	1837 } City. 1859 }	{ Little River. Spruce Lake.	{ Gravity and Pumping. Gravity.	...	Water Power.	}	...	...	...
37	Somerville, Mass.	1868 City.	Metropolitan W.W.	...	...	...	...	...	...	...
38	Springfield, Mass.	1864 City.	Reservoirs.	Gravity.	...	...	...	...	...	...
39	Taunton, Mass.	1876 City.	{ Assawompsett and Elder's Ponds.	Pumping.	Holly, Allis.	Bituminous.	Cumberland.	5 00-8 00	...	...
40	Waltham, Mass.	1872 City.	{ Filter basin near Charles River.	Pumping.	Parr, Worthing- ton.	Bituminous }	Georges Creek, New River.	5 66	12	...
41	Ware, Mass.	1886 Town.	Wells.	Pumping.	Dean, Warren.	Bituminous.	...	5 75	...	5 00
42	Wellesley, Mass.	1884 Town.	Wells.	Pumping.	Blake.	Bituminous }	Puritan, Georges Creek.	5 55	12	3 50
43	Westerly, R. I.	1886 Town.	Driven Wells.	Pumping.	Worthington.	Bituminous.	Georges Creek.	...	...	...
44	Whitman, Mass.	1883 Town.	Well.	Pumping. }	Blake, Worth- ington.	...	...	...	...	...
45	Winchendon, Mass.	1896 Town.	Well.	Pumping.	Blake.	Bituminous.	...	5 45	10	...
46	Woburn, Mass.	1872 City.	{ Filter gallery near Horn Pond.	Pumping. }	Worthington, Blake.	Bituminous }	Georges Creek, Carbon, New River.	5 63	9	...
47	Woonsocket, R. I.	1884 City.	Crook Fall Brook.	Pumping. }	Worthington, Deane.	Bituminous.	Pocahontas.	6 20	10	3 00
48	Yonkers, N. Y.	1874 City.	{ Sprain and Grassy Sprain brooks and Tubular Wells.	Pumping. }	Wright, Worthington.	Bituminous.	Georges Creek.	4 24 to 10 50	...	12 00

² Cost of sawdust, etc., averaged \$6 37 per million gallons pumped.³ Fire supply.

1903. --- TABLE 1, *Concluded*. --- PUMPING STATISTICS.

Number	3	4	4a	5	6	7	8	9	10	11	12
	Coal Consumed for the Year (Lbs.)	Lbs. of Wood + = Equivalent Coal	Amount of Other Fuel Used	Total Equivalent Coal Consumed for the Year (Lbs.) (3) + (4)	Total Pumpage for the Year in Gallons	Average Static Head against which Pumps Work. (Feet)	Average Dynamic Head against which Pumps Work (Feet)	Number of Gallons Pumped per Lb. of Equivalent Coal	Duty in Foot- pounds per 100 Pounds of Coal. No deductions	Cost per Million Gal- lons pumped into Reservoir figured on Expenses	Cost per Million Gal- lons raised 1 Foot Pumping Station Expenses
1	3 369 016 { * 1 340 375 }	4 784 425	...	3 373 800 { * 1 341 000 }	1 432 542 4201 { * 202 701 1142 }	95 120	126 135 { 188 { 225 }	425 151	44 618 600 17 023 600 4	\$9 85 29 53	\$0 078 0 219
2	618 229	..	...	..	170 215 160	..	..	275	53 500 000	...	..
3	4 530 600	3 009	...	4 533 600	1 104 212 781 8	..	113	244	22 953 772	8 89	0 079
5	771 011	..	...	..	405 605 118 8	132	152	525	66 693 171	13 90	0 09
6	295 673	..	...	..	29 151 887 8	275	315	99	25 917 346	70 71	0 22
8	550 246	..	...	..	539 199 314	..	..	..	..	..	..
9	..	..	...	..	319 463 200	289	316	..	..	31 16	0 098
10	4 462 469	500	...	4 462 969	3 160 704 360 8	158	194	..	114 844 888	6 55	0 033
12	63 733 300	..	...	63 733 300	22 633 887 289 8	{ 173 325 }	214	355	63 525 134	4 62	0 022
14	4 793 600	..	...	..	1 561 339 604	..	186	326	..	14 39	...
18	{ 303 6530 2 177 363L	..	...	303 6530 2 177 363L	96 090 2190 { 938 204 252L } 2	2940 152L	3220 185L	3070 431L	83 530 9700 66 756 094L	15 05	0 0930 0 073L
19	{ 8 479 404 3 382 437 5	..	...	8 491 804 3 384 837 5	1 923 370 800	157 5	164 5	227	77 791 512 5	24 03 6	0 146 6
20	3 654 700	..	...	3 654 700	1 873 992 750 2	149	150	513	73 633 725	8 42	0 006
21	1 548 100	..	...	..	530 523 600 7	201	228	..	..	..	..
22	..	..	...	680 000	207 874 800 8	164	172	306	43 851 800	14 22	0 082
23	569 004	..	...	569 004	125 561 428 8	190	212	204	39 223 177	..	..
<i>Station</i>											
<i>Chestnut Hill</i>											
a	22 253	..	...	..	27 510 000	..	44	1 236	48 510 000	11 24	0 225
b	850 524	..	...	..	528 430 000	..	120	621	71 940 000 3	13 14	0 109
c	750 153	..	...	..	776 180 000	..	128	1 035	119 560 000	8 81	0 069
d	8 177 358	..	...	..	9 631 330 000	..	128	1 178	127 750 000	3 98	0 031

	Chestnut Hill	Low	Service	Station			38	3 244	108 380 000 ³	1 50	0 039
	e 8 561 549	..	...	..	..	27 773 230 000 ²	..	..	..	..	..
	Spot Pond										
	f 167 792	..	...	..	..	178 820 000 ^{1 2}	119	1 066	108 200 000 ^{1 3}	6 80	0 057
	g 2 210 587	..	...	..	..	2 570 010 000 ¹	128	1 163	126 020 000 ¹	4 42	0 035
25	585 840	..	...	..	..	90 469 000 ³	182	154	26 273 528	35 70	0 175
26	..	..	33 768 ⁸	19 781 970	..	7 467 840 050 ⁹	{ 204 to 235	..	{ 61 713 864 67 481 179	10 00 13 81	0 042 0 061
27	3 043 426	..	...	3 043 426	167	2 525 860 944 ²	235	830	129 925 914	6 20	0 033
29	3 375 450	6 000	...	3 381 450	234	770 124 560 ³	257	228	48 815 436	18 06	0 07
30	506 000	..	...	506 000	80	55 600 000 ²	80	110	7 173 000	35 80	0 45
31	..	..	...	467 660	65	165 597 696	73	354	21 557 607	17 18	0 22
32	{ 5 358 840 537 900 5 500 1 254 944 1 831	167 .. 5 500 1 831	262 975 ¹⁰ .. .. ..	.. 543 400 1 256 775	171 172 112	4 497 594 533 ² 335 656 058 ² 569 976 223 ²	177 178 128	549 618 454	80 947 800 91 595 200 48 399 300	{ 7 44L 18 79H ⁴	0 042L 0 131H ⁴
33	438 599	..	...	..	219	53 202 932 ³	240	121	24 302 615	73 61	0 306
34	4 163 740	1 800	...	4 165 540	213	1 396 385 444 ³	258	335	72 130 636	7 69	0 030
35	1 352 100 ¹¹	0	...	1 352 000	..	637 321 000 ²	{ 160 300	..	..	..	..
39	{ 1 165 000 409 900	.. ..	...	1 165 000 409 900	..	554 664 539 454 749 430	69	476	27 374 223	14 16	0 205
40	1 328 695	..	...	..	164	822 773 150 ³	180	{ 624 282	95 043 181	11 07	0 062
41	619 203	1 533	...	620 736	221	119 379 180 ³	244	192	39 136 099	22 20	0 09
42	607 450	260	...	607 710	260	107 202 000	280	176	41 193 728	29 96	0 107
43	1 367 310	..	...	..	195	246 014 500	210	180	{ 29 487 000 35 915 000	25 45	0 121
45	261 931	..	...	261 931	246	37 530 490 ²	289	168	40 330 070	29 46	0 101
46	1 953 400	..	...	..	200	502 997 250 ³	216	258	46 386 780	18 04	0 084
47	1 624 100	533	...	1 624 633	238	365 776 417 ²	239	225	44 893 958	16 50	0 069
48	5 789 945	..	...	..	185	1 743 770 168	251	..	..	16 32	..

* 13 months.

1 By Venturi Meter.

2 With allowance for slip.

3 Without allowance for slip.

4 Water pumped twice.

5 West Sixth Street Station.

6 Low Service.

7 Estimated.

8 Cords of sawdust, etc. One cord is

equivalent to 585.8 lbs. of coal.

9 Of this, 6 522 658 950 gallons were

pumped by steam power.

10 Gallons fuel oil costing \$ 0.375 per

gallon.

11 Water power pumps in use most of

time, but fires kept under boilers.

12 High service.

L Low service.

a Engine No. 1. (Low service.)

b Engines Nos. 1 and 2.

c Engine No. 3.

d Engine No. 4.

e Engines Nos. 5, 6, and 7.

f Engine No. 8.

g Engine No. 9.

20 Lynn, Mass.	.	.	.	115 056 71	97 579 70	212 636 41	.	.	.	.	.	.
22 Marlboro, Mass.	1 650 04	.	.	11 497 20	24 041 70	35 538 90	6 760 00	.	.	.	.	.
23 Maynard, Mass.	2 555 32	178 53	.	6 083 17	4 786 65	10 869 82	2 000 00	.	.	.	.	.
25 Middleboro, Mass.	3 444 18	.	.	3 742 98	7 065 10	10 808 08	.	.	.	.	.	.
27 New Bedford, Mass.	{ 20 584 46 12 536 98	3 178 40	.	81 922 00	42 202 26	124 124 26	.	.	.	.	.	.
28 New London, Conn.	15 602 81	.	.	.	.	60 607 34	11 920 00 ³	200 000 ³	.	.	.	.
29 Newton, Mass.	.	.	.	2 894 00	{ 111 445 00 8 905 00 ⁴	123 244 00	.	.	.	.	.	.
30 Oberlin, Ohio	1 092 07	.	.	1 090 00	6 567 80	7 657 80	.	.	.	.	.	.
31 Plymouth, Mass.	.	—1 313 54 ⁵	.	.	.	24 550 13	.	.	.	.	.	.
32 Providence, R. I.	.	.	.	.	.	.	.	.	.	.	.	.
33 Reading, Mass.	{ 49 41 39 30	50 70	.	.	10 155 12	10 155 12	4 890 00	300 00	.	.	.	.
34 Reading, Pa.	55 832 69	0	.	129 842 27	49 726 20	179 568 47	.	.	.	.	.	.
35 Rochester, N. Y.	14 695 45	.	.	145 864 87	266 338 23	412 203 10	.	.	.	.	.	.
36 St. John, N. B.	3 526 05	.	.	.	.	112 737 67	.	.	.	.	.	.
37 Somerville, Mass.	.	.	.	163 170 84	61 164 59	224 335 43	.	.	.	.	.	.
38 Springfield, Mass.	10 637 38	.	.	153 273 49	85 399 64	238 673 13	20 000 00 ³	1 915 60 ³	.	.	.	.
39 Taunton, Mass.	.	1 961 50	.	.	.	63 177 66	.	489 97 ⁶	.	.	.	.
40 Waltham, Mass.	3 465 59	4 665 23	.	55 645 43	13 754 71	69 400 14	.	.	.	.	.	.
42 Wellesley, Mass.	5 299 11	.	.	0	14 126 95	14 126 95	4 000 00 ⁷	.	.	.	.	.
43 Westerly, R. I.	.	.	.	1 977 19	24 874 79	.	{ 825 00 2 500 00	.	.	.	.	.
46 Woburn, Mass.	.	.	.	37 596 23	7 958 45	45 554 68	.	275 00	.	.	.	.
47 Woonsocket, R. I.	.	.	.	2 481 78	57 652 16	60 133 94	16 675 00	2 658 25	.	.	.	.
48 Yonkers, N. Y.	14 162 22	9 814 05	.	.	.	136 923 19	27 270 00	.	.	.	.	.

¹ Paid at meter rates, and included in Receipts — Meter Rates.
² Fines.
³ Overdrawn.

⁴ For three months.

⁵ Bookkeeping account only; no cash received.
⁶ Includes also fountains and street watering.

⁷ Meter rents.

20	.	.	.	.	.	.	.	.	.	238 945 27	9 654 08	461 235 76
22	.	.	.	.	.	.	.	.	.	.	1 949 01	46 121 77
23	.	.	.	120 00	.	.	.	.	.	.	1 132 00	17 355 67
25	.	.	.	.	.	.	.	.	.	.	{ 208 98 341 08	16 302 32
27	.	.	.	.	.	.	.	.	.	.	.	241 604 10
28	1 500 00 ³	.	.	.	.	.	.	.	.	103 221 73	411 21	194 163 09
29	3 000 00	2 324 00	.	.	.	.	.	.	.	32 417 20	4 950 40	165 935 60
30	.	.	.	.	.	.	.	.	.	10 000 00	682 15	22 415 90
31	.	.	.	.	.	.	.	.	.	20 023 33	1 703 77	46 963 69
32	.	.	.	.	.	.	.	.	.	.	.	.
33	500 00	.	.	.	.	.	.	.	.	.	284 80	17 869 33
34	.	.	.	.	.	.	.	.	.	.	9 040 64	244 441 80
35	.	.	.	.	13 423 56 ⁴	.	.	.	.	.	{ 12 263 04 13 672 23	566 757 38
36	.	.	.	.	.	.	.	.	.	22 000 00	7 123 52	145 387 24
37	.	.	.	.	.	.	.	.	.	.	6 061 60	230 397 03
38	6 118 25 ³	12 605 75 ³	.	.	.	.	.	.	.	.	{ 1 756 00 ³ 907 79	313 758 87
39	.	578 13	.	.	.	.	.	.	.	.	{ 637 33 4 574 84	81 368 93
40	.	.	.	.	2 031 41	.	.	.	.	8 000 00	4 217 93	91 780 30
42	.	141 74	84 00	.	.	.	.	.	.	5 000 00	1 788 35	30 440 15
43	.	.	.	.	.	.	.	.	.	3 256 57	{ 2 274 37 4 886 83	.
46	250 00	792 00	.	.	.	.	.	.	.	1 800 00	{ 744 53 679 06	.
47	2 867 72	1 053 72	745 31	14 500 00	.	.	.	.	.	.	83 58	98 717 52
48	.	.	.	.	.	.	.	.	.	127 643 83	2 112 99	.

^a From sinking fund, for payment of bonds.

^b Excess of income of sinking fund.

¹ Paid at meter rates, and included in Receipts — Meter Rates.

² Included in part in Receipts — Meter Rates.

³ Book-keeping account only; no cash received.

⁴ Franchise tax from vacant lots.

1903.—TABLE 2, Continued.—FINANCIAL STATISTICS.

Number	MAINTENANCE EXPENDITURES			DD Interest on Bonds	EE Payment of Bonds	FF Sinking Fund	CONSTRUCTION EXPENDITURES					KK Total Construc- tion
	AA Operation	BB Special	CC Total Mainte- nance				GG Extension of Mains	HH Extension of Services	II Extension of Meters	JJ Special		
1	\$59 176 32			\$57 643 00		\$36 211 82	\$13 091 46	\$5 913 98	\$2 820 20	\$25 168 26	\$46 993 90	
2			\$14 049 40	13 845 00		5 200 00			1 196 49		29 898 40	
3	16 223 09		16 223 09	19 190 00	\$20 000 00		11 796 70		797 50		12 594 20	
4	1 728 55	\$5 701 23 ¹		1 460 00	2 250 00	520 00	4 982 45	743 43	511 91		6 237 79	
6			2 715 90	3 600 00		1 800 00						
7	827 286 89 ^a	{ 1 510 857 46 ¹ 2 324 04 }		411 050 00	1 574 000 00		15 487 85 ¹					
8	24 941 42			44 450 00			278 921 43	2 173 08	2 603 80		283 698 31	
9	30 093 67			9 920 00				869 31				
10	28 753 48	33 036 13	61 789 61	133 086 50		121 522 50	8 429 25	2 499 90	2 212 51	15 711 79	28 853 45	
11	15 599 19	32 178 83 ¹	47 778 02	12 000 00		5 410 00	1 391 15	937 65	42 34	977 85	3 348 99	
12	260 092 95		260 092 95	131 360 00	0	0	223 253 76	0	213 755 89	407 911 66 ²	844 921 31	
13	9 073 32			25 050 00			16 840 74	2 025 21	1 023 38			
14			54 482 87	97 525 00							20 000 00	
16			30 648 16	12 875 00		26 378 06	33 479 30		62 40	55 469 87	89 011 57	
17	2 398 26			3 532 52								
18												
20	89 588 39		89 588 39	91 144 95		41 127 45		6 212 53		129 806 60 ³	136 019 13	
22	9 019 92		9 019 92	21 520 00							1 922 26	

23	4 451 39	.	.	.	.	4 451 39	5 000 00	.	.	.	.	1 457 87	1 073 05	357 25	560 42	3 448 59
25	5 570 35	.	.	.	.	5 570 35	2 060 00	.	.	.	5 500 00	11 55	178 11	.	.	189 66
27	76 148 46	.	.	.	.	76 148 46	74 180 00	30 000 00	.	.	12 000 00	34 022 11	7 078 91	2 858 40	619 95	44 579 27
28	7 908 77	.	.	.	.	7 908 77	21 915 00	.	.	.	.	5 577 35	1 407 78	705 36	51 222 61 ⁴	58 913 10
29	22 606 00	.	.	.	.	.	100 475 00	.	.	.	.	6 270 07	9 626 18	3 466 26	{ 15 002 00 ⁵ 3 003 09 }	37 367 60
30	3 499 29	.	.	.	.	.	752 50	2 000 00	.	.	.	445 45	537 32	747 67	15 154 41	16 884 85
31	11 778 38	.	.	.	.	.	4 668 99	7 640 00	.	.	.	5 080 59	405 55	.	14 933 75	20 419 89
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	7 609 02	.	.	.	.	7 609 02	8 705 00	.	.	.	.	62 56	1 059 56	292 38	64 88	1 479 38
34	50 430 68	1 545 24	.	.	.	51 975 92	16 572 00	.	.	.	7 500 00	25 420 33	0	3 486 43	113 891 84	142 798 60
35	117 325 68	.	.	.	.	117 325 68	220 282 01	.	.	.	55 000 00	34 855 80	.	.	2 457 98	37 313 78
36	31 357 12	928 14	.	.	.	32 285 26	67 022 14	.	.	.	12 093 64	17 263 96	.	.	160 31	17 424 27
37	26 360 17	{ 77 288 431 14 860 60 }	.	.	.	.	5 610 00	23 000 00	.	.	.	6 006 80	2 750 95	5 299 53	109 93	14 167 21
38	25 351 17	{ 15 879 74 211 63 18 157 63 }	.	.	.	.	61 000 00	.	.	.	116 954 00	13 147 42	.	.	10 686 49	23 833 91
39	29 133 23	.	.	.	.	.	33 343 00	.	.	.	2 406 86	7 496 19	3 717 18	1 203 79	1 490 67	13 907 83
40	25 371 04	.	.	.	.	25 371 04	17 465 00	.	.	.	28 000 00	.	.	.	.	10 741 36
42	6 590 48	52 02	.	.	.	6 642 50	11 200 00	.	.	.	.	5 460 71	1 087 28	207 60	.	6 755 59
43	11 898 56	.	.	.	.	.	14 350 41	.	.	.	2 000 00	.	.	.	.	8 929 24
46	13 995 10	.	.	.	.	.	2 660 00	.	.	.	29 929 88	1 594 30	1 671 49	.	.	.
47	14 622 32	.	.	.	.	14 622 32	32 280 00	.	.	.	.	.	.	.	.	13 875 65
48	76 518 40	.	.	.	.	.	83 050 00	.	.	.	21 000 00	.	.	.	.	102 325 61

⁴ Barnes Reservoir, etc.⁵ Water Rights.¹ Metropolitan Water Assessment.² Tunnels, Pumping Station, etc.³ Increased storage.^a This is an expenditure for maintenance and extensions from one appropriation; no division of it can be made under those heads.^b From loan; in addition to expenditures for extensions included in A.A.

1903.—TABLE 2, *Concluded*.—FINANCIAL STATISTICS.

Number	LL Unclassified Expenses	MM BALANCE		N Total	Disposition of Balance	O Net Cost of Works to Date	P Bonded Debt at Date	Q Value of Sinking Fund	R Average Rate of Interest, Per cent
		aa Ordinary	bb Extraor- dinary						
1	. . . .	\$85 380 97	\$67 139 39	\$152 520 36	. . . . .	\$1 302 402 62	\$1 250 500 00	\$31 500 00	4 64
2	. . . .	. . . .	6 036 93	. . . . .	. . . . .	451 853 83	357 000 00	57 805 91	. . . .
3	. . . .	10 803 01	. . . .	78 810 30	City Treas.	630 907 90	342 000 00	. . . . .	5 6
4	. . . .	1 382 81	144 14	19 424 52	. . . . .	. . . . .	36 000 00	3 790 87	4 0
6	. . . .	. . . .	. . . .	8 115 90	. . . . .	92 286 31	90 000 00	9 296 71	5 0
7	. . . .	. . . .	284 512 15	4 625 518 39	Forward	16 025 824 04	8 227 000 00	7 337 902 79	4 40
8	. . . .	27 755 30	52 405 28	433 250 31	. . . . .	1 327 533 62	1 225 000 00	471 696 49	3 75
9	. . . .	6 378 13	. . . .	47 261 11	. . . . .	476 504 71	248 000 00	49 000 00 ¹	4
10	\$6 925 51	. . . .	. . . .	352 177 57	. . . . .	5 750 655 15	3 350 600 00	1 062 821 46	3 5 & 4
11	. . . .	40 494 30	. . . .	109 031 31	City Treas.	491 552 68	300 000 00	71 787 00	4
12	5 829 98	. . . .	354 368 62	1 596 572 86	. . . . .	9 085 086 45 ²	3 555 000 00	0	4
13	. . . .	11 148 89	. . . .	65 161 64	. . . . .	896 755 42	630 000 00	. . . . .	. . . .
14	. . . .	138 261 85	. . . .	310 269 72	. . . . .	2 010 354 46	2 080 000 00	768 669 29	4 7
15	43 032 96	25 825 63	. . . .	68 858 63	City Treas.	387 430 48	512 000 ³ 00	124 569 52	. . . .
16	5 154 37	11 601 46	. . . .	175 668 62	. . . . .	1 295 308 26	350 000 00	64 477 39	. . . .
17	. . . .	27 032 74	. . . .	32 963 50	City Treas.	. . . . .	. . . . .	. . . . .	. . . .
18	. . . .	. . . .	. . . .	. . . . .	. . . . .	2 244 872 33	752 000 00	48 620 56	5
20	. . . .	. . . .	103 355 84	461 235 76	Construction.	2 810 680 54	2 167 300 00	696 434 17	4

22	.	13 659 59	.	46 121 77	.	589 805 24	538 000 00	200 453 78	4
23	1 574 83	2 880 86	.	17 355 67	Forward	160 000 00	125 000 00	25 000 00	4
25	.	2 830 80	151 42	16 302 32	.	118 605 66	48 500 00	11 671 65	4
27	.	1 517 97	3 178 40	241 604 10	Forward	3 231 340 41	1 668 000 00	240 181 79	4 36
28	30 000 00 ³	75 436 22	.	194 163 09	.	952 224 88	601 000 00	.	3 59
29	.	5 487 00	.	165 935 60	.	2 151 974 16	2 185 000 00	1 061 179 00	4 6
30	86 26	—970 00 ⁴	.	22 415 90	.	109 210 27	51 000 00	.	3 8
31	.	.	2 456 52	46 963 69	Construction	350 378 01	124 039 80	.	3 5 to 4
32	.	.	.	.	.	6 569 925 22	6 000 000 00	1 562 158 44	3 75
33	.	75 93	.	17 869 33	Forward	287 833 69	216 000 00	.	4
34	940 45	24 654 83	.	244 441 80	Forward	2 213 725 08	400 000 00	21 190 00	4
35	2 074 78	23 610 85	.	455 607 10	.	7 822 355 23	5 610 000 00	205 000 00	3 5 to 7
36	.	11 775 53	4 786 40	145 387 24	Forward	1 581 676 00	1 403 400 00	55 457 00	4
37	1 137 84	67 972 78	.	230 397 03	City Treas.	815 997 35	123 000 00	.	4
38	40 554 60 ⁵	11 816 19	.	313 758 87	Sinking Fund	2 241 904 17	875 000 00	119 657 41	4 27
39	.	.	2 628 01	81 368 93	Sinking Fund	1 307 884 77	830 200 00	271 323 58	3 5 & 4
40	.	4 061 10	6 141 80	91 780 30	Forward	626 858 20	445 000 00	189 286 50	3 88
42	950 70 ⁶	4 768 82	122 54	30 440 15	Forward	337 051 38	283 000 00	113 293 77	4
43	.	.	.	.	.	363 422 37	.	47 342 08	.
44	.	.	.	.	.	134 412 75	100 000 00	.	4
46	.	.	.	.	.	603 182 68	46 300 00	1 699 46	4
47	.	.	.	.	.	273 601 96	832 000 00	116 939 53	3 8
48	.	.	35 132 27	180 568 40	.	1 779 310 12	1 660 000 00	373 900 69	5 33

⁴ Overdrawn.⁵ To City Treasury.⁶ To town treasury.¹ Ab ut.² After allowing for depreciation.³ Charged to city (book account) for municipal use of water.

1903. — TABLE 3. — STATISTICS OF CONSUMPTION OF WATER.

Number	Name of City or Town	Estimated Population			4	5	6	Average Consumption (Gallons per Day)			11	12
		Total at Date	On Line Supplied of Pipe at Date	Total				To Each Inhabitant	To Each Consumer	To Each Tap		
1	2	3	Total Consumption for the Year (Gallons)	Quantity Used through Meters (Gallons)	Percentage of Consumption Metered	Total	To Each Inhabitant	To Each Consumer	To Each Tap	Figured on Total Maintenance (Item CC)	Figured on Total Maintenance + Increase on Bonds (Item CC)	
1	Atlantic City, N. J.	36 000	35 500	150 000 ^a	1 448 154 650	..	{ 3 967 546 5 656 335 ^a	110 38 ^a	..	842	\$36 19b	\$71 44 ^a
2	Attleboro, Mass.	13 000	12 500	..	170 215 160	..	406 342	33	37	..	..	..
3	Bay City, Mich.	29 000	21 500	18 000	1 104 212 781	19	214 503 147	104	108	1 252	14 60	32 07
4	Belmont, Mass.	4 400	4 200	4 000	..	All	40 377 500	25 ^c	26 ^c	172 ^c	..	..
5	Beverly, Mass.	15 237	15 237	15 237	405 605 118	11	44 875 000	73	73	318	..	..
6	Billerica, Mass.	2 850	1 850	1 485	29 151 887	..	..	79 868	53	..	93 19	217 76
7	Boston, Mass.	597 900	..	597 900	..	..	6 748 022 160	..	..	..	..	..
8	Brockton, Mass.	45 500	44 000	40 000	539 199 314	55	299 205 468	32	37	253	..	..
9	Burlington, Vt.	19 400	18 900	18 800	319 463 200	59	191 253 000	45	46	248	..	..
10	Cambridge, Mass.	96 685	96 685	96 685	3 160 704 360	34	1 074 317 752	90	90	589	19 55	60 31
11	Chelsea, Mass.	34 000	34 000	34 000	..	..	179 587 485	..	..	..	..	..
12	Cleveland, Ohio	438 000	435 000	428 000	22 633 887 289	35	7 998 778 320	142	145	1 054	11 49	17 19
13	Fall River, Mass.	113 602	..	112 602	1 561 339 664	..	..	4 277 643	38	..	..	..
14	Fitchburg, Mass.	34 000	..	29 000	1 006 000 000 ^d	..	..	2 750 000 ^d	..	95 ^d	..	..
15	Holyoke, Mass.	48 973	48 673	48 398	1 837 188 080 ^d	..	470 267 250	103	104	1 353	..	..
16	Keene, N. H.	10 000	9 500	8 800	..	..	..	..	..	..	..	..
17	Lawrence, Mass.	70 000	..	66 500	1 034 294 471	58	600 979 500	41	43	437	59 65	90 67
18	Lynn, Mass.	81 000	80 000	80 000	1 875 197 646	25	490 000 000	63	64	365	48 00	100 00
19	Madison, Wis.	20 000	..	18 792	530 523 600	28	149 141 152	73	78	..	..	..
20	Marlboro, Mass.	14 000	13 500	12 900	207 874 800	42	88 077 800	41	44	252	43 39	146 91
21	Maryard, Mass.	5 000	3 500	..	..	..	125 000	70	..	500	36 40	75 61
22	Met. W. W., Mass.	900 500	..	..	39 109 120 000	..	..	107 148 000	119	..	..	..
23	Middleboro, Mass.	4 500 ^e	4 200	3 900	90 469 000	43	39 156 157	55	63	281	61 57	84 34
24	Minneapolis, Minn.	225 000	175 000	155 000	7 467 840 050	25	1 844 069 125	91	132	..	..	..
25	New Bedford, Mass.	72 000	63 000	62 000	2 535 280 580	31	772 887 000	96	112	700	30 04	59 29
26	New London, Conn.	22 000	20 800	20 000	564 988 000	..	..	6 945 974	70	77	14 00	52 79
27	Newton, Mass.	37 600	36 900	36 700	769 809 852	63	484 000 000	56	58	290	..	..
28	Oberlin, Ohio	4 800	4 000	3 000	55 600 000	39	21 700 000	32	51	190	71 00	76 50
29	Providence, R. I.	202 800 ^f	..	202 800	4 786 834 205	60 ^d	..	13 114 614	65	65	143 20	306 63
30	Reading, Mass.	5 000	4 860	4 485	53 202 932	33	1 256 943 346	29	32	570	13 76	18 14
31	Reading, Pa.	86 300	86 130	86 310	3 778 588 178	..	..	10 324 000	120	120	..	..

35	Rochester, N. Y.	171 000	171 000	171 000	5 618	884 175	1	832	085 000	34	15 394 118	90	90	476	20 88	60 08
36	St. John, N. B.	44 743	43 099	43 099	2 621	125 200		543	861 600	21	6 414 948	143	149	1 098	12 33	37 88
37	Somerville, Mass.	68 000	68 000	68 000	2 120	650 000 ^g		426	055 257	20	5 810 000	85	85	....	....	....
38	Springfield, Mass.	66 446	60 000	54 000	4	270 500 000 ^h		549	780 743	13	11 700 000 ^d	176 ^d	1 117 ^d	....	....	....
39	Taunton, Mass.	31 036	28 000	27 350	554	664 539		262	995 415	47	1 519 629	49	54	320	30 84	52 08
40	Waltham, Mass.	25 650	25 250	25 200	822	773 150		71	555 428	8	2 254 173	88	90	655	....	....
41	Ware, Mass.	8 263	7 974	7 850	119	379 180		72	351 710	62	327 066	40	42	409	61 12	164 38
42	Wellesley, Mass.	5 417	5 362	5 324	107	202 000		55	085 961	51	293 704	54	55	315	....	....
43	Westerly, R. I.	13 500 ^h	12 000	11 000	246	014 500		....	....	..	672 170	56	61	464	....	....
44	Whitman, Mass.	6 469	....	....	37	530 490		12	765 727	34	....	....	....	....	....	....
45	Winchendon, Mass.	5 395	3 300	2 676	502	997 250		69	364 458	14	102 823	19	31	192	72 20	168 42
46	Woburn, Mass.	14 250	14 200	14 200	365	667 963		286	190 728	78	1 350 667	97	97	451	....	....
47	Woonsocket, R. I.	35 974	35 474	35 474	1	743 770 168		971	883 226	56	1 001 830	28	28	392	39 98	128 26
48	Yonkers, N. Y.	56 000	55 000	55 000	1	743 770 168		....	....	....	4 777 452	85	88	842	....	....

a In summer.
b 13 months.

c Based on service meters.
d Estimated.

e Of fire district.
f Includes suburbs.

g Part measured, part estimated.
h Includes also Watch Hill and Pawcatuck.

1903.—TABLE 4.—STATISTICS RELATING TO DISTRIBUTION SYSTEM.—MAIN PIPES.

Number	Name of City or Town	Kind of Pipe	2	3	4	5	6	7	8	HYDRANTS		11	12	13	14	15
										Length Extended During the Year (Feet)	Total Length in Use (Miles)					
			SIZES OF PIPES (Inches)	Length Extended During the Year (Feet)	Length Discarded During the Year (Feet)	Total Length in Use (Miles)	Cost per Mile	Number of Leaks per Mile	Length of Pipe Less than 4 Ins. Diam. (Miles)	Number Added	Total in Use	Number Added	Total in Use	Number of Pipes smaller than 4-inch	Blow-off Gates	Range of Pressure on Mains (Pounds)
1	Atlantic City, N. J.	C. I.	4-20	14 200	444	57 5	.....	.....	2 7	28 1	620 1	33	.....	.....	4	35-55
2	Attleboro, Mass.	W. I., C. I., Cem. L.	1-16	24 249	.....	43 6	.....	0 5	.....	22	329	23	.....	.....	.....	54-62
3	Bay City, Mich.	C. I., Wyckoff	4-20	11 747	6 805	48 2	\$17 10 1	8	.....	13 1	443 1	.....	759	.....	12	35-90
4	Belmont, Mass.	C. I.	4-12	3 753	.....	18 7	.....	0	0 5	6	147	.....	233	20 11	.....	15-100
5	Beverly, Mass.	Cem. L., C. I.	1-24	.....	.....	64 7	.....	2 3	.....	7	293	16	577	.....	.....	60-65
6	Billerica, Mass.	C. I.	6-12	.....	.....	9 7	.....	1 3	.....	.....	101	.....	84	.....	4	54-120
7	Boston, Mass.	C. I.	6-48	78 910	53 572	732	.....	0 3	2 1	68	7 837	150	9 446	10	.....	25-95
8	Brookton, Mass.	W. I., Cem. L., C. I.	6-30	61 254	750	85 8	4 37 0 4	0 9	56	752	62	979	16	39	47-56	.....
9	Burlington, Vt.	C. I., Cem. L., W. I.	4-30	1 924	460	39	3 19 0 3	4	2	216	9	661	66	14	70-85	.....
10	Cambridge, Mass.	C. I.	2-40	1 209	.....	125 4	5 05 0 0	3 2	4 1	1 005	.....	14	.....	0	45-55	.....
11	Chelsea, Mass.	C. I.	4-16	1 650	.....	38 8	.....	3	0 1	5	.....	7	416	6	31	50-75
12	Cleveland, Ohio	C. I.	3-48	90 631	.....	594	33 76 0 4	2	150	6 838	412 12	877	6	0	20-90	.....
13	Concord, N. H.	.....	.....	14 528	12 249	62 2	.....	.....	.....	5	282	16	816	.....	.....	.....
14	Fall River, Mass.	C. I.	6-24	.....	.....	95	.....	.....	.....	29	1 060	30	1 050	.....	.....	80
15	Fitchburg, Mass.	C. I.	2-30	5 890	.....	69 1	.....	.....	.....	13	529	8	581	.....	.....	75-55
16	Holyoke, Mass.	C. I., W. I., Ld. L.	4-30	10 686	.....	85 4	2 28 0 1	5 7	2	775	8	810	15	36	45-100	.....
17	Keene, N. H.	W. I., Cem. L., C. I.	4-24	7 712	.....	40 0	2 70 1 1	3 2	8	228	5	383	31	31	58-63	.....
18	Lawrence, Mass.	C. I.	1-30	9 905	2 527	83 7	.....	7 6	4 1	604	36	1 075	0	13	65-125	.....
20	Lynn, Mass.	Cem. L., C. I.	4-36	795	.....	135	136 00 1 6	.....	.....	2	965	10	1 002	66	40-60	.....
21	Madison, Wis.	C. I.	.....	3 904	.....	39 0	.....	.....	.....	7	201	10	275	.....	2	53-65
22	Marlboro, Mass.	C. I.	4-16	0	0	36 6	0 95 0 1	0 9	0	346	0	390	19	65	35-142	.....
23	Maynard, Mass.	C. I.	4-12	2 150	.....	9 6	0 58 0 2	.....	2	92	4	89	2	2	80-95	.....
24	Met. Water Works.	C. I., Cem. L.	6-60	11 100 2	.....	84 2	.....	.....	.....	.....	.....	25	353	.....	.....	.....
	Met. Water Dist., {	C. I., Cem. L., Kal.	4-60	195 500 2	.....	1 494 1	.....	.....	.....	178	13 111	.....	.....	.....	.....	.....
	Total in cities and towns															
25	Middleboro, Mass.	C. I.	4-12	.....	.....	17 3	.....	0	0	.....	121	.....	178	0	6	40-60
26	Minneapolis, Minn.	C. I., W. I., Steel	6-50	41 503	83	286 6	.....	0 3	.....	71	3 412	87	2 452	45	.....	25-95
27	New Bedford, Mass.	C. I.	4-36	13 553	1 811	100 1	10 36 0 2	0 9	19	998	40	1 172	114	99	.....	35-45
28	New London, Conn.	Cem. L., C. I.	4-24	9 425	0	59 8	6 09 2	16 1	4	332	11	377	.....	34	.....	.....
29	Newton, Mass.	C. I.	4-20	2 520	.....	139 3	1 50 0	0 3	3	966	4	819	48 394	2	80-86	.....
30	Oberlin, Ohio	C. I.	4-12	532	.....	10 5	0	0	0 3	1	97	1	67	2	2	27-32

[illegible]¹ Elevators only; number of motors unknown.

UP TO 1895 — SOME REMINISCENCES.

BY R. C. P. COGGESHALL, SUPERINTENDENT NEW BEDFORD WATER WORKS.

[Read September 14, 1904.]

It was my privilege, two years since, to present to you an historical sketch treating of the beginning and early days of this Association.* Grouped around the historical facts there enumerated were woven a series of reminiscences with the idea of giving color and added interest. The object of that paper was threefold:

1. To place before you a clear and authentic statement of the conditions under which the Association was organized.

2. To emphasize the credit due that little band of modest but earnest workers who so securely constructed the foundation upon which the superstructure of our society now rests, and made the act of organization on June 21, 1882, a possibility.

3. To place upon the records of this Association all facts connected with the organization period in such a way as to completely disarm future controversy as to the acts of those days.

I do not wish to be understood as hinting that there had ever been any important controversy over these matters, but twenty years witness many changes in an Association of this character. Few of the original number remain in active touch with its affairs at the end of such a space of time. It, therefore, is not strange that a majority of the present membership know little concerning our early life.

Previous to presenting my former paper, there had been many misstatements made in public concerning these matters, and, I am sorry to add, by those who ought to have known better. Claims regarding our origin widely at variance with the real facts had been made. Even our birthplace was claimed by more than one locality.

* "Twenty Years After — A Retrospect." — Journal of the N. E. Water Works Association, December, 1902, Vol. XVI, p. 271.

Such was the condition when one day, a few years since, the president of the Salem Water Board, in welcoming the members of the Association to a banquet in that city, made the astonishing statement that it was fitting that we should again return to the scene of our birth, that event having occurred at the pumping station of that city at Wenham Lake.

Our Salem friend was undoubtedly innocent enough in his statement. He did not know himself. Somebody had told him so. That somebody's imagination had added the item of birth to the actual fact of a visit to the Salem pumping station several months after the organization of this Association in Boston.

After hearing of so many places where we had come into existence, some of the "old guard" members began to feel, with "Topsy," that we never were born. I can sympathize with our "Martin Luther" friends of Lowell in the pleasure of celebrating the birthday anniversary of an illustrious leader twice a month, or more frequently if one finds himself in proper spirit so to do, but when it comes to location of birth, most of us prefer to know that it occurred once only at some well-defined place.

In the minds of many of our older members it seemed as if better information regarding our early days was sadly needed. My former paper was an attempt to supply that need. How well it accomplished its mission is for others to judge. But it appeared to meet your favor, if the many solicitations for a continuation of those reminiscences is any index. In the supplementary series on which I am now about to enter, I have no such prominent object in mind as was the case in the former paper. Consequently, what I now have to say may fail to appeal to you as favorably as did the former address.

My former paper treated of the period commencing with our early days, and concluding with the New Bedford Convention in June, 1886. Henry W. Rogers, then superintendent at Lawrence, had just been installed as president. Albert S. Glover and Edwin Darling were continued in their respective positions as secretary and treasurer.

Henry W. Rogers* possessed a type of manhood that we do well to honor. Scrupulously honest and unusually clearheaded

* A portrait of Mr. Rogers accompanies the earlier article.

and well equipped in his chosen work, he commanded the respect and regard of every one who came in contact with him. He knew his business thoroughly. He possessed a sensitive nature, was easily upset by political interference, and was naturally very shy and retiring; so he was apt to remain very quiet at our gatherings unless his opinion was sought. His clear statements were always valued, for they were filled with common sense. This Association never possessed a more loyal and interested member than Henry W. Rogers. During the latter part of his presidency he resigned his position as superintendent of the Lawrence Water Works, and became agent for Maxcy & Lewis, of Maine, then well-known contractors for various water construction projects. His work located him for some time at Calais, Me.

He relinquished his connection with Maxcy & Lewis in 1889, becoming superintendent at Salem, Mass. In 1891 he accepted the superintendency at Milford, Mass. The following year we find him superintendent at Haverhill, Mass., which position he continued to fill until 1898. He then established a small coal business at Roxbury, Mass., which he soon relinquished on account of failing health. He returned to Haverhill in 1899, and died in that city in April, 1901.

An important item to chronicle in connection with Mr. Rogers' administration was the appearance of the first issue of the present quarterly JOURNAL of this Association, in September, 1886. At the previous June convention the Association had decided to establish this publication, and had elected W. R. Billings, then superintendent at Taunton, and the writer, as editors. This publication has since continued to appear with the close of each quarter. Neither editor possessed previous experience with the work which he undertook. But that did not matter. Both took hold with a hearty good-will and a determination that the experiment should not fail for want of push. Being located only twenty miles apart, it was easy to have frequent meetings. We gave much study to the general typographical appearance of the publication. I feel that we did well, for the general style then adopted has remained with little change up to the present time. It was not an easy matter to find material for each number in those days. I had quite a number of interviews with Prof.

W. S. Chaplin, then at the head of the Lawrence Scientific School of Harvard University, before I could persuade him to contribute his paper, entitled "Water in Japan," which appeared in the second issue. I had a similar experience in obtaining from T. M. Stetson, Esq., a noted lawyer in my city, his argument in favor of a Fall River Water Act, which appears in the June, 1887, issue. So we got along somehow, and the way gradually appeared easier, for the publication soon began to attract attention outside the ranks of the Association.

At the invitation of President Rogers, the September field day meeting of 1886 was held at Lawrence, Mass. It consisted of a reception, light lunch, visit to the Pacific Mills, the water works pumping station, display of fire department, banquet, speeches, and benediction. One incident occurred in connection with the visit to the Pacific Mills which I do not recall as having been heretofore told. Just as the party was about to start from the city hall for the mill, Mr. Parker, one of the superintendents of that corporation, came to me and told me that he was very much disturbed at the receipt of a message announcing that a certain Mr. —— would probably be in our party. This individual was a well-known expert connected with a rival corporation, and his presence would not be agreeable upon the floors of the Pacific Mills. We failed to locate any one answering the description furnished by Mr. Parker. So we had a dummy telegram prepared addressed to the individual in question. Just as the party was about to enter the mill, I jumped upon the steps, held up the telegram, and called out the name. No one responded. We soon learned from some of our members that the individual in question had not arrived. Whereupon the mill officials felt decidedly more comfortable.

The following December the quarterly meeting was held at the Quincy House, Boston. This, and a meeting held in January at Young's Hotel, were mainly devoted to matters of experience. In February, 1887, Hiram F. Mills, C.E., a member of the then newly organized State Board of Health, gave an outline of work upon which that organization was about to enter. He dwelt in detail upon those matters having special interest for the members of this Association. That was the beginning. We can now tes-

tify our appreciation of the admirable work which has since been accomplished by this board. At the same meeting, Prof. George F. Swain made his bow to the Association, presenting an able paper upon the "Influence of Forests upon Rainfall." The following month, March, 1887, saw the quarterly meeting at which Albert F. Noyes, then city engineer at Newton, gave his paper on "The Driven Well System as a Source of or a Means of Obtaining a Water Supply." This paper attracted considerable attention.

The sixth annual convention occurred at Manchester, N. H., on June 15, 16, and 17, 1887. President Rogers was unavoidably prevented from attending this convention, and he sent word at the last minute. Secretary Glover had great difficulty in inducing a vice-president to act as presiding officer. He went down the list, and one after another asked to be excused, until he came to Willard Kent, our present accomplished secretary. He kindly consented to help out as best he could. He filled the position with credit to himself, and to the great satisfaction of all present. In the long list of those elected to membership at this time, I note the following well-known names: Rudolph Hering, Frederic P. Stearns, W. E. McClintock, Prof. George F. Swain, George A. Kimball, J. J. R. Croes, Louis H. Knapp, Prof. Albert R. Leeds. There were several interesting papers presented, and a number of topical discussions followed. Among the most important papers presented was one on "Mixing and Handling of Concrete at Ashland Basin No. 4," by Wilbur F. Learned, and another on the "Aëration and Filtration of Water," by the late Charles B. Brush, C.E., of Hoboken, N. J. A brilliant discussion by Prof. Albert R. Leeds of the Stevens Institute at Hoboken followed the presentation of the last-named paper. He had a fine platform presence, a ready flow of language, and an interesting and attractive method of presenting his subject. Consequently he commanded the attention of all his listeners. Both Mr. Brush and Professor Leeds were earnest workers, but their work in this world has since been closed by the icy touch of death.

Jason Giles was then the Manager of the Chapman Valve Manufacturing Company. He was very popular. During a discussion upon the subject of "Hydrants" at this convention, he was

invited to speak. He did so, showing so much tact that he was roundly applauded when he finished.

The subject of hotel accommodations has always been and still remains a fruitful source of criticism. Conventions seldom occur where every one is wholly satisfied. In the majority of conventions a large amount of fault-finding is in evidence from this cause. There is no question that the enthusiasm of many of our early attendants was dampened by unsatisfactory hotel service. Right here I am going to relate an instance which occurred at this Manchester convention. The hotel selected for headquarters lacked capacity. We were crowded in all sorts of ways. A number of the older members occupied cots set up at night in the room reserved for the secretary's office. Others doubled up in rooms as best they could. Among the company was George H. Frost, President of the Engineering News Publishing Company of New York. He shared a room with others. They did not agree as to the proper use of the room. Frost went to his room at night for the purpose of wooing the sleepy god. Some of his comrades were not inclined that way. At a late, or rather early, hour there occurred an incident which rendered sleep impossible for the remainder of the night on the part of Frost. When he appeared in the morning, he was filled with righteous indignation. A person of his quiet taste could hardly be expected to be in sympathy with the treatment which he received from his roommate. His interest in the convention vanished, and he immediately left for home. I think that he has never appeared at any of our meetings since. Previous to that time he had taken a great personal interest in our affairs, both by attendance at our meetings and by helpful service in many other ways. In appreciation of all this, the Association had elected him an honorary member at the New Bedford convention the previous year. He must have had an enjoyable time at that gathering, for evidence of which note the following extract from an editorial which appeared in the *Engineering News* of June 26, 1886:

"It is quite impossible for a superintendent of water works to theorize on the advantages of attending a convention such as this while seated comfortably in his office a day's journey distant, or busily engaged in superintending actual work in his department. Reading the published reports in a newspaper

or in the transactions of the Society is but a partial substitute for actual attendance. One must meet in person his fellow experts, see what kind of men they are, engage in conversation at the meetings and elsewhere, catch the opinions that never reach the stenographer or newspaper reporters, visit the points of interest, see the numerous appliances on exhibition that are never described in the reports, make the acquaintance of the manufacturers and their agents who are in attendance, enjoy the good fellowship that abounds, and in general obtain the benefits of a delightful outing in company with a select band of kindred spirits.

"All this and more made the convention at New Bedford a pleasant three days' vacation; the expense was trifling, the benefits immense in comparison; the city government and water commissioners were assiduous in their efforts to entertain the visitors, and they succeeded admirably; while the indefatigable president and secretary of the Association managed to keep everything in the smoothest of running order,—after the example of the excellent machinery at the pumping station, under the control of the president,—so that nothing was lacking to render the meeting a genuine success, viewed either as an intellectual tournament or a social gathering."

In contrast to this, let me present the following from the editorial column of the same publication of June 25, 1887, shortly after the experience heretofore related regarding the Manchester convention:

"The next annual meeting will be held at Providence, R. I. It is a satisfaction to note this action on the part of the Association. The hotel accommodations at Manchester were most unsatisfactory, and it has been abundantly demonstrated that the average New England hotel in cities of the size of Manchester cannot provide for an immediate inroad of one hundred and twenty-five extra guests, so it was considered advisable to seek accommodations in the larger city. There is no doubt that good food, well served, and, above all, a comfortable bed to spend the night in, are important elements to the success of any gathering such as these conventions are. If men come to the meetings weary in body and mind, hungry and sleepy, they cannot be expected to feel much enthusiasm over the subject in hand. It is simply the national disposition that allows the average American to submit to the regular imposition of the average innkeeper. Americans are the most patient and submissive people in the world; if there is any part of America where good hotels should be the rule and not the exception, it is in New England, and it is the duty, an absolute obligation of a body of men such as met in Manchester last week, to express their feelings of dissatisfaction where they are not properly treated."

The hotel accommodations at Manchester were fully as good as they were the previous year at New Bedford. That in my

own city I know to be inadequate to satisfactorily cater for one of our three days' conventions. Without doubt there were many at New Bedford who suffered from poor service. But our friend did not happen to be one of that number. On the contrary, he appears to have been well cared for on that occasion.

When it is possible to provide attractive and comfortable service, it is indeed a pleasure to have the convention of this Association meet at our respective home cities. But the city or town that lacks proper hotel accommodations had better refrain from urging such a gathering to assemble within its borders, rather than to risk the result that many may return to their homes dissatisfied with the hotel treatment they have experienced. There are really very few cities in New England to-day that contain hotel equipments adequate for such an occasion as our three days' convention.

At the close of this convention Edwin Darling became president; R. C. P. Coggeshall, secretary; Albert S. Glover, treasurer; Prof. George F. Swain, senior editor; William R. Billings, junior editor. The Association had now reached a degree of prosperity where it was decided to allow a salary of three hundred dollars and traveling expenses to its secretary.

The last day of this convention was devoted to a program of entertainment prepared by Manchester friends. The day was perfect and the program went off without a hitch. In the morning we took a drive through different parts of the city, stopping first at Superintendent Walker's comfortable "old Colonial" home, when under the spreading elms we partook of refreshments, which afterwards were washed down with Massabesic water artistically combined with something attractive to the palate, and which caused the stock on hand to disappear like dew before the morning sun. Then a little later another stop was made at Commissioner Chandler's home, when a similar program was indulged in. We then proceeded to the train for Lake Massabesic, the source of the water supply of the city of Manchester. Arriving, the pilgrims were conveyed across a short arm of the lake by a funny little steamer named *Joe Cobb* to Fletcher's Island, where a shore dinner was served, followed by speech-making and amusements of various sorts.

There were several ex-governors of New Hampshire in the party that day. One of them remarked that he felt certain that the New England Water Works Association was an excellent institution to prevent scarcity of water supplies, for he had seen them on many occasions and noticed that they always tasted it, but finding it an old acquaintance, they endorsed it, saying that it was very good, and then passed to try the next. John Hosley, then mayor of Manchester, was in evidence everywhere that day. So was the water registrar, Walter E. Stearns, who did much personal work during the entire convention in enhancing the personal comfort of the visitors.

Edwin Darling was president of this Association from June, 1887, to June, 1888. He possessed a tremendous energy, indomitable will, and vigorous but narrow intellect. He had many of the qualities of good leadership. He had very positive opinions upon all matters, and was extremely fond of having his own way. There was nothing bashful in his makeup. If he wanted an office he frankly said so, and asked you to support him: witness his effort for election to the presidency of this Association for a second term, in June, 1888. But, withal, he was an extremely kindhearted man, and no one ever wanted to be upon the popular side more than he. Of his integrity and honesty there is no question. He felt that he was the natural leader of the Association; and as long as he could maintain a prominent position in our affairs his interest continued; but a few years later, when his influence waned, he resigned his membership. He lived only a few months after leaving this Association.

The September meeting of 1887 occurred upon the steamer *Mt. Washington*, on Lake Winnepesaukee. All that was done was to add a few names to our membership roll.

Commencing with the following December, there occurred four successive monthly meetings at Young's Hotel, Boston. Among notable papers presented at this period were those by Prof. T. M. Drown on "Odor and Color of Surface Waters," and by Prof. W. T. Sedgwick on "The Biological Examination of Water." Among well-known names added to our membership roll at this period appear those of George E. Evans, R. A. Hale, and the late Charles H. Swan.



EDWIN DARLING
President of the New England Water Works Association
1887-88

The Providence convention occurred June 13, 14, and 15, 1888. The headquarters of the Association were at the Narragansett Hotel. The sessions were held at the Veteran Fireman Association Hall. The hotel arrangements were a decided advance, viewed from the point of comfort, over anything we had heretofore experienced. But, as I look back, it seems to me that this convention was the most uninteresting of any I ever attended. The very oppressive weather which came at this time probably contributed to the lack of inspiration evident on every hand. Then I have felt that the program was not as attractive as it might easily have been made. Some of the members were so affected that they left for home before the close. I was in a gloomy state of mind, and well remember the help given me by a talk with our always "level-headed" friend, Charles K. Walker, in the hotel lobby at the close of the last session. Among those who joined the Association at this time were Thomas M. Drown, J. Herbert Shedd, George F. Chace, J. A. Gould, and Charles E. Bolling. Among the papers presented were "Tubular Wells," by the late W. C. Boyce; "Soils from which Water Supplies may be Drawn by Filter Galleries," by the late Phinehas Ball; "Aëration" and "Relief Valves," by S. E. Babcock; "Covered Reservoirs," by the late Charles H. Swan; "Testing of Water Meters," by L. Frederick Rice, and a lecture illustrated by lantern slides upon the method of building the new Croton aqueduct, by Prof. J. E. Denton, of Hoboken, N. J. The concluding feature of this convention was an excursion down Providence River upon the last day, with a landing at Crescent Park, where the party partook of a shore dinner.

Hiram Nevons, of Cambridge, became president at the close of this convention; R. C. P. Coggeshall was reelected secretary; Albert S. Glover was reelected treasurer; Prof. George F. Swain was elected senior editor; and Walter H. Richards, junior editor.

Hiram Nevons, the seventh president of this Association, was then the superintendent of the Cambridge Water Works. He was a man of good executive ability. He was tender and sympathetic in all the relations of life. Strong in his personal attachments, he possessed a cheerful and welcome presence, which impressed every one who came in contact with him. Having a

deeply religious nature, he introduced during his administration the offering of grace at the opening of each of our functions. To him should be ascribed the introduction of music as a feature in the programs of our meetings. His administration was very successful.

In September, 1888, there occurred a field-day gathering at Cambridge. After an inspection of the various features of the Cambridge water system, there followed a banquet, tendered by the city government and the Water Board.

During the following winter there occurred the four usual monthly meetings at Young's Hotel, Boston. Among the prominent papers presented were: "The Construction and Maintenance of Water Works," by the late Hon. Chester W. Kingsley; "Safe Ratio of Pumping Capacity to Maximum Consumption," by William B. Sherman; "Water in Some of Its Higher Relations," by Rev. D. N. Beach. In addition to the above, a large number of brief experience papers were presented and discussed.

We note the following names, among others, of new members elected during this period: John R. Freeman, Louis E. Hawes, Prof. Charles F. Chandler, William Paul Gerhard, Freeman C. Coffin, Horace L. Eaton, Byron I. Cook, Prof. Dwight Porter, Capt. James L. Lusk, and James L. Gale, the last-named being elected an honorary member.

The eighth annual convention, which occurred at Fall River, on June 12, 13, and 14, 1889, was one of the most enthusiastic gatherings we ever had. It was like a stiff southwest breeze from start to finish. There was something doing all the time, and no wonder, when one realizes that the entertainment features were directed by Patrick Kieran, William M. Hawes, and W. W. Robertson, all Fall River men. Those of us who have enjoyed the gracious hospitality of Patrick Kieran know that he is an artist of the first rank upon such occasions. I verily believe that Patrick Kieran is in his happiest mood when engaged in making bountiful provision for the entertainment of some friend. As for William M. Hawes, what a host he was! He always knew how to say in a cheery way the right thing at the right time, and merry peals of laughter were sure to follow. He was undoubtedly one of the most popular members our Association has ever had.



HIRAM NEVONS

President of the New England Water Works Association

1888-89

Our sympathy went to him a few years later when he was attacked by that long fatal illness, and when the end came we keenly felt that we had, indeed, lost a loving friend.

Among the papers presented at this convention were: "Hydrants," by George A. Stacy; "The Richmond Water Works," by Charles E. Bolling; "Friction in the Collection of Meter Rates," by George F. Chace; "Recent Progress in Biological Water Analysis," by Prof. W. T. Sedgwick; "Water-Works Records," by Albert S. Glover; "Pumping Engines," illustrated by lantern slides, by Prof. J. E. Denton. Among the names here added to the membership roll appear L. M. Hastings, E. H. Keating, and Robert K. Martin.

One incident was the acceptance of a gavel, which was presented from J. M. Diven, secretary of the American Water Works Association.

At the close of this convention Dexter Brackett became president, R. C. P. Coggeshall was reelected secretary, Hiram Nevons was elected treasurer, F. H. Parker, senior editor, and Albert S. Glover, junior editor.

Shortly after this election a photographer appeared at the hotel with a camera, for the purpose of obtaining a snapshot of the newly elected president, for insertion in the newspaper report of the convention. Had the photographer requested a sitting, his request would, undoubtedly, have been granted, but he undertook to get the picture unbeknown to his subject. His object was discovered, and then followed some very amusing attempts to get the desired picture, all of which failed.

President Nevons brought his choir with him. The leader and bass singer was Francis L. Pratt, then the city messenger of the city of Cambridge. He was a fine singer and a fine leader. He was in constant attendance at our meetings for many years, and his singing was always popular. Whenever there was any lull in the discussions, President Nevons would make a requisition on the choir for an inspiring selection. It had the effect of making things lively. I think the closing exercises of this convention the most unique of anything of the sort that I ever attended. Everything was bubbling over with good cheer. Excitement was rampant, and all hands acted like a parcel of overgrown

schoolboys bent upon making a great big noise. At the close, the actions were pretty near the dimensions of a "breakdown" or a "cake walk." All hands were on their feet, — some dancing, some beating time, while the singers whooped it up on some two or three dozen verses of "Mary had a Little Lamb" to the tune of the "Battle Cry of Freedom." The congregation joined in the chorus:

"Hurrah for Miss Mary!
Hurrah for the lamb!
Hurrah for the teacher,
Who didn't care a ——!
For we'll rally round the flag, etc."

The word "damn" was emphasized by the singers and the president with the explosion of dynamite torpedoes. William M. Hawes was an imposing spectacle as he stood upon a chair, thoroughly excited, waving his handkerchief, cane, and spectacles. Things grew blue and dusty, and thus the Fall River convention came to a close.

Charles E. Bolling, the able superintendent at Richmond, Va., and Capt. James L. Lusk, then in charge of the Washington, D. C., Water Department, made their first appearance at this time. Mr. Bolling made his bow to the Association with a carefully prepared paper, reviewing the details of the works under his charge. A few years later I was entertained by both of these gentlemen in their respective home cities. Mr. Bolling possesses a very attractive personality, and would be sure to become popular in any body with which he associated. Later he became the president of the American Water Works Association. Captain Lusk was, a few years later, transferred from Washington to service in other branches of the army. Neither of these gentlemen ever attended many of our meetings; I suppose the long distance made it an impossibility. As both were strangers to our section of the country at that time, I have often wondered what sort of an impression the unusual scene described above must have made upon them.

The ex-presidents whom I have heretofore mentioned, and who filled the space from the time of my presidency, in 1886, up to this period, have all faded from earthly sight. Dexter Brackett,



DEXTER BRACKETT

President of the New England Water Works Association

1889-90

who assumed the presidency at this time, is an ex-president who is still young, very much alive, and a familiar figure to you all, and, what is still more to the purpose, he proposes to keep up his youthful ways and indomitable energy as long as he lives. He put a tremendous amount of labor into the work of his administration. There was no lack of inspiration while his hand was at the helm. He was a working president in every sense that the word implies. His deep interest in our affairs continues unabated, and the many helpful services which he is constantly rendering are always appreciated.

In the matter of entertainment, our Fall River friends offered a full program. At the close of one of the afternoon sessions the Association visited the new High School Building and inspected every part. In the hall in the upper part of the building is a marvelous cartoon by Kaulbach, entitled "The Era of the Reformation." The salient features of this picture were described by one of the lady teachers.

The last day was devoted wholly to entertainment. A visit to the pumping station was followed by a steamboat excursion. A landing was made at Bullock's Point, on the Providence River, where a shore dinner was served. In the speech-making which followed the dinner, some one referred to Rhode Island as a fertile state, to which William M. Hawes ventured the sally that she ought to be a fertile state, as she had the whole filth of Massachusetts draining down upon her. At the conclusion of these exercises the steamer was again boarded, and the party proceeded as far as Newport, where a landing was made. Leaving Newport, a direct return was made to Fall River.

In the following month of September an excursion was made to the White Mountains. Under the leadership of President Brackett, the party left Boston on the 29th, took dinner at the Pemigewasset House at Plymouth, and late in the afternoon arrived at the Crawford House, White Mountain Notch. Here they remained over Sunday. Visits to various points of interest were made upon that day. Our friend Joseph E. Beals made an involuntary test of the temperature of the water of "Beecher's Cascade," which those who witnessed will never forget — and I don't believe he ever will, either. The scenery upon

that quiet Sunday was grand. The mountain sides were ablaze with brilliant glory of autumnal tints, while the summits were capped with glistening snow. The return trip was made on Monday by the way of North Conway, where a stop was made and the party driven to various points of interest, after which a dinner was served at the Kearsarge House. It was a most enjoyable trip. We had our own private car, and many will remember our friend who rigged himself appropriately and acted as "water boy" to the party. We arrived in Boston that night in a drenching rain.

Early in December the series of monthly meetings was resumed at Young's Hotel, Boston. At the first meeting John R. Freeman, the eminent hydraulic engineer, presented one of the most valuable productions ever published by this Association. I refer to his well-known paper entitled, "Some New Experiments and Practical Tables Relating to Fire Streams." The January and March meetings were devoted to the presentation and discussion of short papers covering a wide range of subjects pertaining to our daily work. At the February meeting Mr. F. F. Forbes contributed an excellent study of "Algae Growths in Reservoirs and Ponds." At this same meeting Prof. William T. Sedgwick joined our list of active members.

I have many times received tangible evidences of the good-will and esteem of the members of this Association. Twice this has come in the form of a generous surprise, which completely overawed me for the time. You will remember that I served as your secretary from the day of your organization until June, 1884, when I retired in favor of Albert S. Glover. At a field meeting three months later, at Woodland Park Hotel, Auburndale, Mass., I was called up, and William R. Billings, in your behalf, presented me with a magnificent engraving of Guido Reni's "Aurora." This incident was followed by Charles K. Walker addressing me, stating that he had been requested to give me a good caning. After humorous remarks, he placed a beautiful gold-headed cane, appropriately engraved as to occasion and date, in my hands. These treasures now adorn my home, and always bring pleasant memories to my mind as I view them. Then again upon the day of my marriage (April 29, 1890), there appeared

at the home of my bride a magnificent case of solid silver, accompanied with an elaborately carved solid oak writing desk. These came with your good wishes. It was a wonderfully pleasant surprise. I have never been able to adequately express my gratitude for the prominent part which you played in making that day for me what it ought to be in every similar case, *i. e.*, the happiest day in a man's life.

The ninth annual convention occurred at Portland, Me., June 11, 12, and 13, 1890. This convention will always remain noted as supplying a practical exponent of the element with which we deal. Water fell in profusion, and we were tempted to cry aloud to Heaven to deliver us from our friend. Of course the elaborate program of entertainment prepared by our Portland friends was completely upset by the drenching rain. We were to have gone to Lake Sebago upon the last day, but it was impossible to do this. Instead, we started for our respective homes. Some of our party, feeling that a second flood had been inaugurated, emulated the example of a certain Mr. and Mrs. Noah,— who, together with Ham, Shem, and Japheth, dodged impending disaster by fleeing to a certain ark, — and took passage to Boston by boat, feeling sure that as long as they were afloat they would be reasonably safe. But they gave no thought to the high wind, and when the boat gave evidence that she had reached the open ocean, then it was that Horace Holden, Frank Andrews, Uncle Jonas Clark, of Northampton, and others commenced to suffer with other troubles all their own. There was very little sleep upon the mighty deep that night.

It was a merry party which indulged in a trolley ride the evening before the convention opened. There were Mr. and Mrs. Brackett, Mr. and Mrs. Glover, Mr. and Mrs. Ross, Mr. and Mrs. Phipps, Mr. and Mrs. Coggeshall, and others whom I do not now recall. For over two hours we rode through various streets of Portland. We attracted considerable attention from the natives because of our vocal attainments. "Annie Rooney" was a popular selection then, and it surely was more than popular with our party that night, judging from the number of times it was repeated. It was a beautiful night, but we saw no more decent weather until after the close of the convention.

Our headquarters at Portland were at the Falmouth Hotel. Here it was that on the evening of the second day the Portland Water Company gave an elaborate banquet in our honor. We had fine music, and the banquet was followed by a set of interesting speeches. One of the drawbacks to our hotel quarters was the fact that the city of Portland was entertaining the Montgomery Light Guards, of Boston, at the same hotel at the same time, which had the tendency to make our accommodations somewhat cramped. George P. Wescott was treasurer of the Portland Water Company. He is at present, and has been for many years, a very prominent figure in many business enterprises throughout Maine. He was greatly interested in the success of this convention, had rendered valuable help in the preparation of the program, and had made generous provision in the matter of our entertainment at Sebago Lake. While he is a man of tremendous energy and push, the ceaseless rain at this time was too much for him, and thus his efforts failed to materialize.

Among the papers presented at this convention were: "The Effect of Water Hammer on Main Pipe and How Remedied," by J. C. Hancock, superintendent at Springfield, Mass.; Prof. William T. Sedgwick spoke upon "Surface Water for Drinking Purposes"; A. W. Locke, then engineer in charge of the Hoosac Tunnel, since deceased, presented some engineering notes made in Holland in 1887; P. F. Crilly read a paper entitled, "Why I Favor the Use of Cement Pipe"; G. A. Roullier, superintendent at Flushing, N. Y., read a paper entitled, "Water Meters, the Advisability of Their Use"; John A. Gould, of Boston, spoke concerning "Recording Gages"; C. W. Morse, of Haverhill, read a paper upon "Comparative Merits of Public and Private Management of Water Works," and one afternoon Alphonse Fteley, the chief engineer of the New York Aqueduct Commission, gave a very interesting and instructive talk upon the new Croton aqueduct, beautifully illustrated by lantern views.

At this convention Albert F. Noyes, of West Newton, was elected president, the incumbents of the offices of secretary, treasurer, and editor being continued in their respective places.

No member ever had a deeper interest in the welfare of this

Association than did Albert F. Noyes, our ninth president.* Joining this Association soon after its foundation in 1882, he remained a constant and enthusiastic attendant of its various gatherings until his tragic death in the Park Square Station in 1896. He was one of the most unselfish and sunny men I ever met. A pleasant speaker, always ready to take part in the discussions, his opinions were highly prized because of his wide experience, close observation, and sound common sense. He made many contributions to our literature, all of which appear in the pages of our JOURNAL.

In the month of September following, a very successful excursion was made to the Franconia Mountains. The party left Boston on Saturday. Dinner was served at the Pemigewasset House at Plymouth, and the Profile House, Franconia Notch, was reached late on Saturday afternoon. Here the party remained over Sunday, returning to Boston on Monday, *via* Pemigewasset Valley route.

The usual series of winter monthly meetings was held at Young's Hotel, Boston, commencing December 10. They were well attended and were very successful. Prominent among the papers presented at this period were: "Secular and Local Variations of Weather and Climate as Affecting Water Supplies," by Prof. W. H. Niles, president of the New England Meteorological Society; "The Filtration of Natural Waters," by Prof. Thomas M. Drown; "The Effect of Storage upon the Quality of Water," by F. P. Stearns, then engineer of the State Board of Health; "The Soft Answer," by L. H. Gardner, superintendent, New Orleans, La.; "Typhoid Fever in Its Relations to Water Supplies," by Hiram F. Mills, C.E.

The sessions of the tenth annual convention were held in Putnam Phalanx Hall, Hartford, Conn., on June 10, 11, and 12, 1891. There were not so many prominent papers presented at this convention as had been the case heretofore. The papers were largely descriptive of some personal experiences. E. E. Farnham, of Sharon, presented "An Experience with Water Hammer"; H. G. Holden, of Nashua, presented a paper entitled "Are Lead Pipe Connections for Iron Service Pipes Desirable?"

* A portrait of Mr. Noyes was published in the JOURNAL of March, 1897 (Vol. XI, p. 195)

J. C. Hancock, of Springfield, presented the subject, "The Risks Taken by a City or Town in having but One Supply Main"; George F. Chace, of Taunton, read a paper entitled, "Three Years' Experience with a Direct Pumping System"; Freeman C. Coffin, of Boston, presented a paper entitled, "Standard Flanges for Water Pipes"; Lucian A. Taylor gave a description of the New Haven Water Company's dam at Woodbridge, Conn.; F. F. Forbes, of Brookline, read an able paper entitled, "The Relative Taste and Odor Imparted to Water by some Algæ and Infusoria, and Thoughts Suggested by Studies in this Direction."

Besides the above there were a number of brief experience papers presented, and several topical discussions were introduced.

In his annual address delivered at the opening of this convention, President Noyes stated that "there has been a growing feeling among many of the members that the Association should have permanent headquarters." This was the first suggestion in that direction. At one of the later sessions a committee of five was appointed to take the matter into consideration and to report recommendations.

At one of the sessions a committee was also appointed to consider the question of a suitable badge, and to report recommendations.

One of the pleasant features of this convention was the music. The Cambridge musicians, led by Francis L. Pratt, who were introduced to us by Hiram Nevons when he was president, were present. It is hardly necessary to add that their work was almost always extremely satisfactory. I say almost always, because, owing to no fault of theirs, there was one occasion during this convention that they made a most ludicrous appearance. It occurred during a reception in the parlors of the Allyn House, at the close of the evening session upon the second day. The piano in the Convention Hall was all right, but no one had thought to look over the piano in the hotel. In reality it was in a horrible condition. When the musical program of that evening commenced, that piano gave out some of the most wretched discords you can possibly imagine. The artists were completely upset. Of course the musical attempt at this time was a flat failure, but everybody laughed and was good natured about it.

At the end of this convention, the Hartford Water Board enter-

tained the members of the Association with a ride to their storage lakes.

At the close of this convention, Horace G. Holden, of Nashua, assumed the presidential chair. The writer was reelected secretary; Hiram Nevons, of Cambridge, was reelected treasurer; Dexter Brackett succeeded F. H. Parker as senior editor; Walter H. Richards, of New London, succeeded Albert S. Glover as junior editor.

Albert S. Glover, who now retires from the office of junior editor, was one of our charter members. He served as secretary of this Association from June, 1884, to June, 1887; was treasurer from June, 1887, to June, 1889; and was junior editor from June, 1889, to June, 1891. When this Association was organized, and for a number of years following, he was water registrar of the city of Newton. I look back to many pleasant days spent with him in that city when we were considering the affairs of this organization. No member has the welfare of this Association more at heart than has he from the date of our organization up to the present time. He did an immense amount of work in our behalf. It was he who first suggested the plan of the quarterly JOURNAL, as it is now published, and its instant success was largely due to his intelligent business methods.

Walter H. Richards, of New London, who now became junior editor, had previously filled the same office for the year ending June, 1889. Previous to that time he had served as vice-president for the year ending June, 1885, also was a member of the Executive Committee from June, 1885, to June, 1888. I met him for the first time at the Worcester convention in 1883. At that time he took great interest in William B. Sherman's scheme for the exchange of sketches, and did all any one could do in helping promote that idea. I used to frequently meet him in connection with our affairs, and those meetings were delightfully pleasant and enjoyable. He was a hard and conscientious worker, and no duty assigned to him was ever neglected.

We now come to the administration of Horace G. Holden, our tenth president. As he appears to be pretty lively and healthy at the present time, it would be shocking to attempt any state-

ment having the tinge of an obituary notice about it. He is a familiar figure at our gatherings. You all know him well. His virtues are many, his faults few, his generosity unlimited, his good nature unbounded. You can't help liking him, for he compels every one he meets to do so. He was a member of the "old guard" which organized this Association on June 21, 1882, and he has continued to take an unabated interest in our affairs. He has always been a conscientious worker, and has done his share, and done it well. He has an innate love for the humorous and ridiculous. Nothing pleases him better than to be a participant in a good-natured joke. At one of the winter meetings at Young's during his administration a member was describing his method of laying a line of pipe. In commenting upon some of the details he illustrated the relative position of two objects by placing two silver forks upon the table. Instantly seeing the opportunity for a little fun, Holden put forth a series of very tactful inquiries, which soon resulted in the building of a wonderful model upon that table. It was necessary, of course, to give full play to the imagination to understand the details of this model. The fruit basket represented the reservoir, the main pipe was illustrated by knives and forks, stop gates by individual butter dishes, the standpipe by a banana, and hydrants by salt cellars. It was about as wonderful as the famous model of the Salt Lick Branch of the Pacific Railroad made by Col. Beriah Sellers.

On the 29th of the following September, an excursion was made to Salem, Mass. Here the party was met by representatives of the Standard Thermometer Company. The party was transferred by horse cars to the standpipe of the Peabody Water Works, where the working end of the electric indicator made by the Standard Thermometer Company was exhibited and explained, after which a trip was made to the Town Hall, where the dial end of the same indicator was examined. The factory of the Standard Thermometer Company was next visited, after which the party returned to Salem, and continued by train and ferry to the Corinthian Yacht Club House at Marblehead. Here they participated in an excellent dinner, after which a direct return was made to Boston.

On December 9 the usual series of four monthly meetings was



HORACE G. HOLDEN

President of the New England Water Works Association
1891-92

commenced at Young's Hotel. At this meeting Mr. Frederic P. Stearns, then chief engineer of the Massachusetts State Board of Health, presented a valuable paper entitled, "The Selection of Sources of Water Supply."

At this same meeting a committee was appointed to convey the sympathy of this Association to William M. Hawes, of Fall River, who had then been the victim of a prolonged illness. This resulted in presenting him on Christmas Day with a silver pitcher and goblet properly inscribed.

At the January meeting Mr. Reuben Shirreffs, then second assistant engineer of the East Jersey Water Company, gave an elaborate talk, illustrated with lantern views, upon "The New Water Supply of Newark, N. J., with Special Reference to the Riveted Steel Pipe Conduit."

The February and March meetings were devoted to the presentation and discussion of a number of brief "experience" papers.

The eleventh annual convention was held at Hotel Hamilton, Holyoke, Mass., on June 8, 9, and 10, 1892. In his annual address President Holden suggested a change of time for holding the annual meetings. He also renewed the suggestion of President Noyes, made the previous year, in regard to permanent headquarters, and hoped "that the time was not far distant when we can afford to have good quarters, centrally located."

Prominent among the papers presented at this convention were the following: "Fire Protection," by George A. Ellis; "The Arrangement of Hydrants and Water Pipes for the Protection of a City against Fire," by John R. Freeman; "The Venturi Water Meter," by R. A. Robertson, Jr.; "The Purification of Drinking Water by Sand Filtration," by Prof. William T. Sedgwick; "The Effect of Aëration of Water and Sewage," by Prof. Thomas M. Drown; "The Franklin, N. H., Water Works," by F. L. Fuller. Besides the above there were a number of excellent experience papers and discussions.

The Committee on Badges rendered their report, and the result was the adoption of the badge with which you are now all familiar.

We were treated with great hospitality by our Holyoke friends, and were shown the important features of their city. One after-

noon we were treated to an excellent organ recital, and on the last day we were carried to Mt. Holyoke, at the summit of which we were served with an excellent lunch while enjoying the magnificent view. The Holyoke convention was certainly a most enjoyable outing.

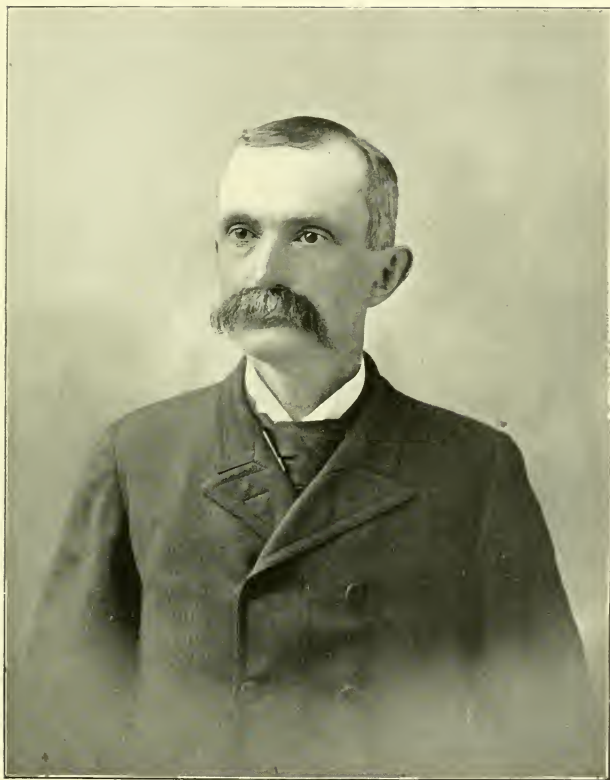
At the close of this convention George F. Chace, then superintendent at Taunton, Mass., became president. The editors, secretary, and treasurer of the previous year were reelected.

George F. Chace is another ex-president who is very much alive at the present time. He is a familiar figure at our various gatherings, and is known to you all as possessing literary ability of no ordinary character. He has presented us with many interesting papers for our discussion and entertainment. He was an excellent president and gave a very successful administration.

The fall excursion took place at Middleboro, Mass., on September 14. The generous hospitality displayed made it one of the most delightful outings in our history. A very pretty and pleasing surprise was a short reception at the Town Hall, when a delegation of ladies, under the leadership of Mrs. J. E. Beals, decorated each member with a boutonnière. Then a lunch followed. Later in the day, after visiting various points of interest, we had a shore dinner at Lake Assawompsett. The entire program was carried out by the entertainers with a life and vim which many a more pretentious affair has lacked. All the visitors were enthusiastic in regard to their reception.

Commencing with December 14, the usual four winter meetings were held. They were almost entirely devoted to short experience papers and discussions of the same. At the December meeting, W. H. Richards, of New London, gave lantern views, with description of features connected with his new "high service" system. At this same meeting, both Desmond FitzGerald and Dexter Brackett gave interesting descriptions of work under their charge, illustrated by lantern slides. We now begin to hear something regarding electrolysis of water pipes; C. H. Morse, of Cambridge, giving us an address upon the subject at the January meeting.

At the February meeting Freeman C. Coffin presented a paper upon "Standpipes," which was followed by Mr. A. Prescott



GEORGE F. CHACE
President of the New England Water Works Association
1892-93

Folwell, who gave a description of a novel standpipe erected at Atlantic Highlands, N. J. At the March meeting Mr. L. M. Hastings presented a paper entitled, "Description of a Method of Estimating the Loss of Water Power in a Stream by Taking Water therefrom for a City Supply." Interspersed among the papers above named were introduced a large number of brief experience papers and topical discussions.

The twelfth annual convention occurred at Worcester, Mass., on June 14, 15, and 16, 1893. The Bay State House, where arrangements had been made for our accommodations, having been damaged by fire a few days previous to the date of our meeting, our headquarters were transferred to the Waldo House. Although our quarters were somewhat cramped, yet we were delightfully entertained. The most important papers include the following: "The Placing of a Large Steel Submerged Pipe in Skaneateles Lake for the Syracuse Water Works," by William R. Hill; "The Works of the East Jersey Water Company for the Supply of Newark, N. J.," by Clemens Herschel; "Purification of Water by Freezing," by Prof. T. M. Drown; "Water Pipe Trenches *vs.* Good Roads," by W. E. McClintock; "Recent Practice in Pumping Machinery," by F. W. Dean; "Is the Game Worth the Candle?" a paper relating to meters, by John Thomson; "An Illustrated Description of the Hydraulic Laboratory of the Massachusetts Institute of Technology," by Prof. Dwight Porter. There were also a number of topical discussions, prominent among which was one on "Details of Pipe Castings and Coating."

The entertainment feature at this convention was elaborate. We were driven to various points of interest. We witnessed the trial of a number of large fire streams. We were carried to Lake Quinsigamond, and to indicate how delightfully accommodating they were, they stopped the train on the passage there to allow Joseph E. Beals to recover his hat which had blown off. At the lake we were entertained in various ways. Those of us who saw Nathan B. Bickford sit for a photo of himself which he presented Charles K. Walker will not be likely to soon forget that event. The dinner and speech-making which followed were delightful, and we returned home well pleased. At the close of the convention George E. Batchelder, of Worcester, became president.

The editors, secretary, and treasurer of the previous year were reelected.

George E. Batchelder had a most attractive personality. He made strong friends of those associated with him. He seldom missed a meeting, and although he was naturally very quiet in his manner, he was not a passive member by any means. His wise counsel and sound advice were always acceptable and respected. He made an admirable president, and at the close of his administration he was elected treasurer, succeeding Hiram Nevons who had then recently died. This position he continued to acceptably fill up to the date of his own death, which occurred in 1899.

The fall excursion of 1893 was held at Plymouth, Mass. It consisted of a visit to the points of historical interest, also a visit to the pumping station of the Plymouth Water Works, followed by a dinner at Hotel Pilgrim. The day was clear and bright. The program was smoothly executed, and every one had a delightful outing.

During the following winter months there occurred the four usual meetings. That of January was held at the Parker House, all the others at Young's Hotel. Prominent on the program appear the following: "Covered Reservoir at Brookline," by F. F. Forbes; "Water Supply at Waltham," by George E. Winslow; "Basin and Well Covering of the Waltham Water Works," by F. P. Johnson; "The Construction of Reservoir Embankments," by Lucian A. Taylor; "The Bursting of the Portland Reservoir," by John R. Freeman; "The Filter at the Wannacommet Water Works, Nantucket, Mass.," by William F. Codd; "The Fairhaven Standpipe," by Joseph K. Nye; "The Electrical Purification of Water," by Prof. T. M. Drown. Intermingled with the above were a number of valuable experience papers and topical discussions.

The thirteenth annual convention occurred at the United States Hotel, Boston, Mass., on June 14, 15, and 16, 1894. The address of welcome given by Hon. Nathan Matthews, Jr., then mayor of Boston, is worthy of more than a passing notice. It was a thoughtful presentation of the financial side of a water-works supply, with suggestions as to how the existing conditions



GEORGE E. BATCHELDER
President of the New England Water Works Association
1893-94

might be improved. Several of the daily papers commented editorially upon it, and during the convention a committee was appointed to take the matter of this address under consideration and to report at a future convention.

The important papers presented at this convention were, "Laying a Sixteen-Inch Main across a Rocky Mill Stream and over a Dam," by George F. Chace; "The Water Service and Fire Protection of Theaters," by William Paul Gerhard; "Remarks Concerning a Recent Paper on the Flow of Water in a Compound Pipe," by George A. Ellis; "Electrolysis of Water Pipes," by C. A. Stone and Howard C. Forbes; "The Care of a Water Meter," by J. C. Whitney; "Experiments with Tube Wells at Lowell," by George Bowers; "The Lawrence Filter and Its Results," by Hiram F. Mills; "What a Water Supply Engineer can do in the Fire Department," by James E. Taylor, of Detroit; "A Few Examples of High-Grade Pumping Engines," illustrated by stereopticon views, by E. D. Leavitt.

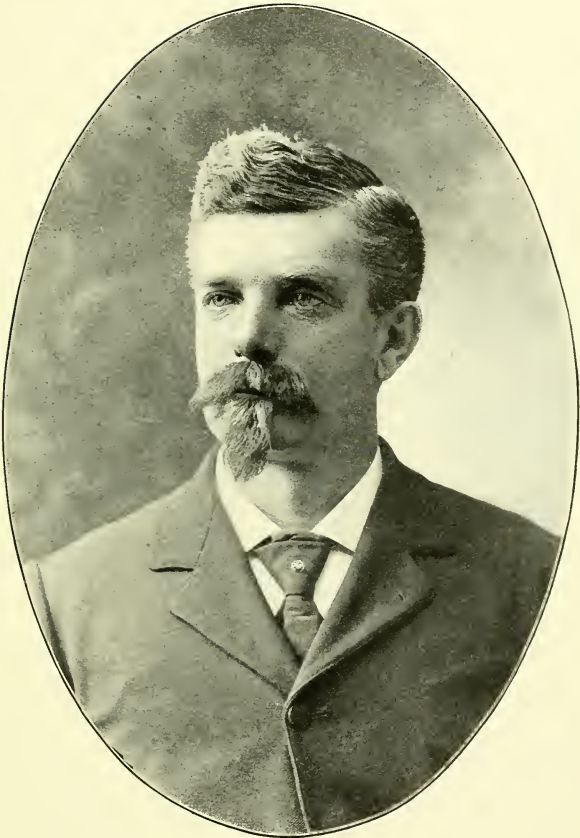
The excursion made during this convention was more largely attended than usual. On Friday a party of over two hundred were taken to Echo Bridge, the Newton, Brookline, and Chestnut Hill pumping stations. On Saturday a still larger party spent the day in a delightful sail around Boston Harbor, stopping at the Sewage Pumping Works and at Fort Warren.

This was a highly successful convention from every point of view. At its close George A. Stacy, of Marlborough, became president. George E. Batchelder was elected treasurer, and the editors and secretary of the previous year were continued in office.

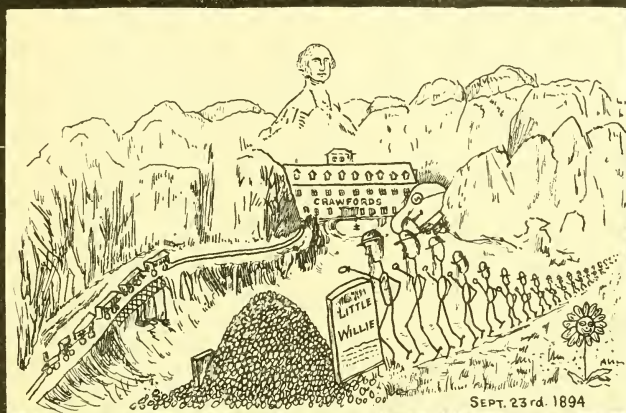
George A. Stacy, the thirteenth president of this Association, joined our ranks in April, 1885. He has always been deservedly popular. He early attained prominence in our affairs by reason of his remarkably intelligent discussion of the various problems brought before us. He has always been willing to do all he could to contribute to the success of our gatherings. He infused into his presidential work the same indomitable energy and push which has always been characteristic of the man. In consequence, he gave us a highly successful administration.

On the following September 22d, an excursion was made to the

Crawford House, White Mountain Notch, and a most delightful Sunday was passed at this spot. Some of the party ascended Mt. Washington, others took in the beautiful view from Mt. Willard. My memory at this time goes back as one of about thirty-five who visited the historic "Willey" House, in an attempt to find some of the relics of the memorable land slide. Visitors were allowed to enter the house. There was an entire absence of such historical relics as might have been provided to appeal to the imagination. One could not imagine a more bare, dirty, and unattractive interior. To some of the party who had been expecting much it was positively repelling. They wanted to get out as quickly as possible. This they attempted to do, but when the door was reached, lo, the doorkeeper blandly held out his hand saying, "Twenty-five cents, please," although nothing had been said regarding this fee when you entered. Some years previous, I had been a victim to this extortion, and it struck me so humorously that I was willing to sacrifice fifty cents to witness the effect upon my wife, who was then visiting the spot for the first time. So we entered the house. I had not dreamed that the remaining thirty-three would follow, but they did. There was absolutely nothing to see except an old piece of dirty straw matting. My wife asked to see the Bible and candlestick, which were relics of the landslide days. They could not be produced. A more disgusted lot of pilgrims you never saw. But as we filed out the door in exit, and each one contributed a quarter into the upturned palm of the keeper, a smile, yea, even more, spread over each countenance. You should have seen George Stacy as I saw him. He shook his head, slapped his arm, burst into a loud laugh, and declared it was the best sell he had ever seen and he would not have missed it for the cost of several quarters. Some one remarked that if this sort of thing had been going on for many years that "Little Willie's grave ought to be covered with a mountain of quarters." Subsequently, William B. Sherman, who was one of the party, made a caricature of the event, a blue-print copy of which he sent to each of the party. I herewith supply a copy of that blue print.



GEORGE A. STACY
President of the New England Water Works Association
1894-95



The following is a list of names which do not now appear upon our membership list, who served this Association in some official capacity previous to 1895.

Henry W. Ayres,
Benjamin S. Babcock,
George E. Batchelder,
William R. Billings,
J. C. Broatch,
J. Stewart Brown,
John L. Congdon,
S. S. Coolidge,
J. Warren Cotton,
Edwin Darling,
Charles R. Dyer,
George A. Ellis,
Sherman E. Granniss,
Walter H. Harding,

John L. Harrington,
John C. Haskell,
James H. Hathaway,
William M. Hawes,
Nathaniel I. Jordan,
Joseph L. Kenney,
James W. Lyon,
Alfred H. Martine,
Willis E. McAllister,
Alvoid O. Miles,
Charles W. Morse,
Hiram Nevons,
Albert F. Noyes,
F. H. Parker,

Henry W. Rogers,	Phineas Sprague,
A. H. Salisbury,	Joseph G. Tenney,
Frederick W. Sawyer,	Herbert F. Whittier.
Henry L. Schleiter,	

Scarcely more than a third of the above list are now living.

By turning back to our records you will note that a group of twenty-seven organized this Association on June 21, 1882. Seventeen of those charter members have served the Association in one or more official capacities. To-day only six of that seventeen remain active in our ranks, *i. e.*, Thomas C. Lovell, Frank E. Hall, Horace G. Holden, Albert S. Glover, Charles K. Walker, R. C. P. Coggeshall.

I will here draw this series of reminiscences to a close. A few months later circumstances compelled me to present my resignation, and my official connection with the Association, as your secretary, came to an end on January 9, 1895.

Since this date the following have served as your presidents:

1895-96, Desmond FitzGerald of Brookline, Mass.

1896-97, John C. Haskell of Lynn, Mass.

1897-98, Willard Kent of Narragansett Pier, R. I.

1898-99, Fayette F. Forbes of Brookline, Mass.

1899-1900, Byron I. Cook of Woonsocket, R. I.

1901, Frank H. Crandall of Burlington, Vt.

1902, Frank E. Merrill of Somerville, Mass.

1903, Charles K. Walker of Manchester, N. H.

1904, Edwin C. Brooks of Cambridge, Mass.

With the exception of Mr. Merrill all those named above were members during my secretaryship.

This paper would not be complete without a testimony of appreciation of the admirable work which has been accomplished by that eminent engineer, Desmond FitzGerald. He joined this Association in 1885. He has until lately been a frequent attendant at our gatherings. His sound discussions and valuable counsels were always a source of profit and inspiration. We all regretted that ill-health compelled him, a year or two ago, to sever his connection with those activities which have been



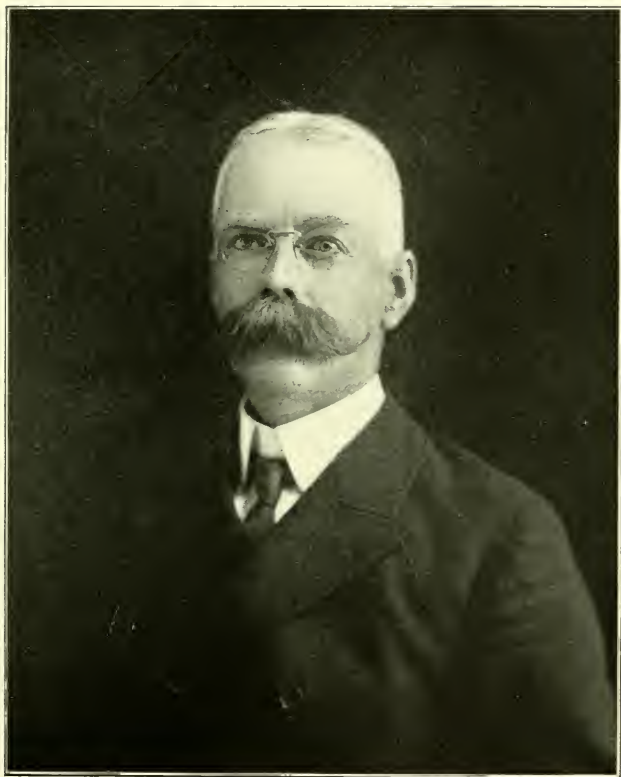
DESMOND FITZGERALD

President of the New England Water Works Association

1895-96



JOHN C. HASKELL
President of the New England Water Works Association
1896-97



WILLARD KENT
President of the New England Water Works Association
1897-98



BYRON I. COOK

President of the New England Water Works Association
1899-1900



FRANK H. CRANDALL
President of the New England Water Works Association
1901

his life work, and are glad to learn that his health is now fully restored.

With the exception of John C. Haskell, all those named above are still good active members of this Association.

You are all familiar with the appearance of the dignified, smooth-faced gentleman who always sits in front of our presiding officer, quietly taking shorthand notes of what is said, but I take it that there are only a very few among us who really appreciate his value as a servant of this Association. He is certainly worthy of your highest praise. He has given you a continuous service from the time of the New Bedford convention, in 1886, up to the present time, and he is indeed an old friend. To the intelligent and well-ordered mind of James P. Bacon should be given a large proportion of credit due for the extremely satisfactory reports of our meetings which appear in the pages of our JOURNAL.

It was always a pleasure to meet our honorary members,—Mr. Frost of the *Engineering News*, Mr. Meyer of the *Engineering Record*, and Mr. Shepperd of *Fire and Water*. These gentlemen rendered us many kind services, and always showed a disposition to do what they could in the direction of enhancing our prosperity. The same is true of our associate membership. There are many in their ranks who have an interest beyond the bounds of trade. More than one excellent paper and many intelligent comments and discussions have been contributed from this class of membership.

But I am here reminded that I have failed to mention a large number of deserving names, all of whom have been important factors in our affairs during the period which I have attempted to cover. There is no question regarding the credit due all such, but to include all of them would be to further extend this paper which has already reached beyond a reasonable limit.

One might judge from the tone of this paper that the Association has had an unusually serene and peaceful existence, and that dissensions apt to be found in such bodies have found no lodgment here. In a way this is true. We have been remarkably free from the effects of strife and animosity. But there have been times when the membership has been divided upon questions which caused more or less feeling. This state of things, however,

never continued long. A way always appeared to quickly smooth the troubled waters. I remember several years since, how that great engineer and no less great man, Alphonse Fteley, rendered this Association a valuable service by acting as arbitrator over a question upon which there was a disagreement among prominent members. His decision was gracefully given, loyally accepted by both parties, and all differences quickly healed and forgotten.

We have now entered upon the twenty-second year of our life. Nearly ten years have passed since I ceased to be prominent in your activities. You did me the honor at that time to say many pleasant things concerning the result of my work. Let me now call your attention to the fact that the Association has since continued to prosper in all good ways. While you have been blessed with leadership equally as good if not superior to that which you had in the past, yet I firmly believe that a large share of our present prosperity is due to our loyal membership. Their aim is high and they do not fall short of the target. The one grand object of this Association is to seek the truth, first, last, and always, never minding where it may be found and whose personal advantage is thereby destroyed. Upon such a foundation the pioneers of this Association began to rear the superstructure of our temple. Thus far we have builded well, and there has been little time when our voyage has been upon other than a calm and placid sea.

I congratulate you upon the past, and predict that, like the well-nourished youth who outgrows his boyhood days, and develops as he enters the ranks of a sturdy manhood, so will this body continue to enlarge its sphere of activities as the years go by, thus enabling it to more satisfactorily cope with any problem in which we are all mutually interested.

PROCEEDINGS.

JUNE EXCURSION.

WEDNESDAY, June 22, 1904.

The June outing of the Association was devoted to a trip by steamboat *King Philip* down Boston Harbor, around the wreck of the steamship *Kiowa*, to Hull, where, by courtesy of Mr. L. S. Doten, the engineer, the party was permitted to inspect the concrete-steel standpipe recently built for the fort; and to Nantasket Point, where dinner was served at the Nantasket Point Hotel. Electric cars furnished by the Old Colony Street Railway Company were then taken, and the party rode to Quincy Point, where the new power station of the company, in which five steam turbines will be installed, is being fitted up. After an examination of the station; the party again boarded the *King Philip* and returned to Boston.

The attendance was as follows:

MEMBERS.

S. A. Agnew, C. H. Baldwin, L. M. Bancroft, E. C. Brooks, Fred. Brooks, G. A. P. Bucknam, James Burnie, G. F. Chace, M. F. Collins, W. R. Conard, G. E. Crowell, E. R. Dyer, E. H. Foster, F. L. Fuller, H. F. Gibbs, J. C. Gilbert, T. C. Gleason, A. S. Glover, R. A. Hale, J. O. Hall, J. C. Hammond, Jr., G. H. Hart, V. C. Hastings, T. G. Hazard, Jr., D. A. Heffernan, H. G. Holden, J. L. Howard, E. W. Kent, Willard Kent, William A. Kilbourn, G. A. King, C. F. Knowlton, H. V. Macksey, D. A. Makepeace, W. E. Maybury, F. L. Northrop, H. E. Perry, G. W. Ricker, W. W. Robertson, G. A. Sanborn, E. M. Shedd, C. W. Sherman, G. H. Snell, G. A. Stacy, J. T. Stevens, J. J. Sullivan, W. F. Sullivan, H. L. Thomas, W. H. Thomas, J. L. Tighe, G. W. Travis, C. K. Walker, G. E. Winslow. — 53.

ASSOCIATES.

Ashton Valve Co., by C. W. Houghton; Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; Fred C. Gifford; Greenwood & Daggett Co., by G. F. Chace; Hart Packing Co., by Horace Hart; Hersey Mfg. Co., by Albert S. Glover and H. D. Winton; Fred A. Houdlette & Son, by

Fred A. Houdlette; Jenkins Bros., by Ernest Schmeliat; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; Mueller Mfg. Co., by H. L. Dickel; National Meter Co., by Charles H. Baldwin and J. G. Lufkin; Neptune Meter Co., by W. H. Van Winkle; Norwood Engineering Co., by H. W. Hosford; Perrin, Seamans & Co., by J. C. Campbell; Rensselaer Mfg. Co., by F. S. Bates and Charles L. Brown; Ross Valve Co., by William Ross; A. P. Smith Mfg. Co., by D. F. O'Brien and F. W. Whitcomb; Sumner & Goodwin Co., by H. A. Gorham; Sweet & Doyle, by H. L. DeWolfe; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by F. L. Northrop; R. D. Wood & Co., by William F. Woodburn. — 28.

GUESTS.

S. M. Spencer, E. A. Winchester, D. L. Millikin, Malden, Mass.; Mrs. Edwin C. Brooks, Cambridge, Mass.; Raymond Kent, East Cambridge, Mass.; Mrs. E. W. Kent, Woonsocket, R. I.; Mrs. C. W. Houghton, F. W. Smith, M. C. Smith, Miss Helen Willson, W. G. Ruggles, Mrs. Horace Hart, Boston, Mass.; Frank L. Weaver, Member Water Board, Charles L. Varnum, James Whittet, Mrs. C. S. Proctor, Lowell, Mass.; Mrs. H. G. Holden, Mr. and Mrs. N. R. Lougee, Miss Gertrude Lougee, Wilder M. Gates, W. H. Greenleaf, Nashua, N. H.; O. P. Richardson, Major E. R. Horton, Attleboro, Mass.; H. D. Parsons, F. H. Dewey, C. N. Oakes, Westfield, Mass.; Mrs. G. E. Winslow, Waltham, Mass.; J. F. Gleason, Mrs. J. F. Gleason, Quincy, Mass.; Mrs. W. E. Maybury, Braintree, Mass.; Mrs. M. E. Phillips, Weymouth, Mass.; John Kelley, Claim Agent Old Colony Street Railroad, Braintree, Mass.; Henry A. Desper, Worcester, Mass.; M. L. Felet, L. P. Stone, Natick, Mass.; Thomas Burke, Mrs. George A. Stacy, Marlboro, Mass.; Mrs. D. A. Heffernan, Milton, Mass.; Mr. McCalhoun, Whitman, Mass.; W. H. Patterson, Providence, R. I.; Mrs. William A. Kilburn, South Lancaster, Mass.; Charles E. Childs, Somerville, Mass.; George W. Fiske, Manager, Fall River Street & Gas Pipe Company, Fall River, Mass. — 44.

(Names counted twice. — 4.)

No business meeting of the Association was held.

EXECUTIVE COMMITTEE.

MAY 19, 1904.

Present: President Edwin C. Brooks and Messrs. Frank E. Merrill, Edmund W. Kent, Horace G. Holden, George E. Crowell, Lewis M. Bancroft; Joseph E. Beals, Charles W. Sherman, George A. Stacy, Robert J. Thomas, and Willard Kent.

Also present: Messrs. Michael F. Collins, of the Committee on

Annual Convention, and William E. Maybury, of the Committee on June Excursion.

A letter from R. D. Wood & Co. in relation to uniformity of hose threads was read, and on motion of Mr. Thomas, seconded by Mr. Bancroft, the President was authorized to appoint a committee of three to consider the subject and report to the Association.

Mr. Maybury of the Committee on June Excursion reported that the Steamboat *King Philip* could be chartered for the day for two hundred dollars (\$200) and that dinner could be secured at the Nantasket Point Hotel at seventy-five (75) cents per plate. Whereupon it was —

Voted : That the date of the excursion be fixed at June 22, and that the steamboat *King Philip* be chartered, and arrangements made with the Nantasket Point Hotel for dinner on that date.

Voted : That Mr. Frank E. Merrill be added to the Committee on June Excursion.

Voted : That Mr. Frank E. Merrill be appointed Transportation Agent to make necessary arrangements with the railroads for reduced fares on the occasion of the Annual Convention in September next, to be held at Holyoke, Mass.

Two applications for membership were received and approved.
Adjourned.

Attest:

WILLARD KENT, *Secretary*.

ON BOARD STEAMBOAT "KING PHILIP,"
Wednesday, June 22, 1904.

Present: President Edwin C. Brooks and Messrs. V. C. Hastings, George E. Crowell, George A. Stacy, Lewis M. Bancroft, Edmund W. Kent, J. C. Hammond, Jr., Horace G. Holden, Charles W. Sherman, Willard Kent.

Eight applications for membership and one for associate membership were received and approved.

Adjourned.

Attest:

WILLARD KENT, *Secretary*.

OBITUARY.

JAMES E. BURKE, secretary and treasurer of the Princeton (N. J.) Water Company, died on February 23, 1904.

Mr. Burke was in his fiftieth year, and had lived in Princeton all his life. He had always been prominent in the public affairs of the community. He was a prominent Democrat, and in 1899 was candidate for the office of sheriff of Mercer County. He had been connected with the Princeton Water Company almost from its inception in 1883. In addition to his position with the water company, he was treasurer of the Princeton Savings Bank, and had been secretary and treasurer of the Princeton Gas Light Company until it was merged into the Princeton Lighting Company.

He was elected a member of the New England Water Works Association on September 11, 1895.

GEORGE DEVERE CURTIS, assistant engineer in the office of the City Engineer of Boston, died June 26, 1904, from an operation for appendicitis.

Mr. Curtis was born August 30, 1863, at Belleville, Ont., and after a public school education, he was, at the age of eighteen, articled for two years to Sir Archibald Ponton, and at once proceeded to the Northwest Territory in the work of the government surveys. In 1883 he came to the United States and entered the employ of the Smead Heating and Ventilating Company, where he remained until 1894. He worked for this firm at various places, among others Toledo, Denver, and Elmira; at the latter place being the manager of the Drafting Department. He designed various systems of heating and ventilating, especially for large

buildings, patenting several improvements along this line. He was a part owner in the company until the financial crash of 1893 came, compelling the failure of the concern.

In the spring of 1895 he entered the City Engineer's office of Boston, where he remained until his death. He was employed on the water works, and did excellent work in designing and systematizing the various castings of the department. He also had charge of the fire supply system for the Boston City Hospital. He was about to patent an improvement in hydrants when his untimely decease occurred. His work always showed the marks of extreme fineness and accuracy.

He combined an even, cheerful temperament with an aggressive ability to achieve results, and his unselfish character was especially noted by all with whom he came in contact.

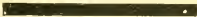
He joined this Association September 19, 1900, and he was also a member of the Boston Architectural Club.

He was married in 1893 to Miss Fannie Hagar, of Richmond, Me., who survives him.

DWIGHT A. HARRIS, superintendent of water works at New Britain, Conn., committed suicide by shooting, and died June 16, 1904.

Mr. Harris was born in Boonville, N. Y., September 17, 1850. He had lived in New Britain about twenty-five years. Having been a plumber by trade, he was at first called in to do odd jobs and make repairs for the water works, which were then too small to require the constant services of one man. Later Mr. Harris was chosen to have the care of the works, and he was superintendent until his death.

He was elected a member of this Association on March 14, 1888.





NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XVIII.

December, 1904.

No. 4.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

THE WATER POWER AT HOLYOKE.

BY ALBERT F. SICKMAN, HYDRAULIC ENGINEER, HOLYOKE WATER POWER COMPANY.

[Read September 14, 1904.]

The successful introduction of cotton manufacturing at Waltham, Mass., and other places, in the early part of the last century, caused a wave of enterprise for manufacturing to sweep over the New England States. Consequent upon that spirit was the development of the water power at Holyoke and the beginning of the upbuilding of this locality in wealth and population.

In 1845 the power at Lowell came under the control of a company organized solely to operate that water power. About two years later the Essex Company, another water-power corporation, completed its dam at Lawrence, and in the same year a charter was granted to the Hadley Falls Company, which, among other things, gave authority to build and maintain a dam on the Connecticut River at Hadley Falls.

Some small use had been made of the water power there prior to that time, water having been taken from the river by means of wing dams, and from the navigation canal on the South Hadley side. But it remained for the Hadley Falls Company to plan and lay out works with a view of utilizing the entire fall of the river and its entire low water flow.

In 1792 a charter had been granted for the building of dams and canals for navigation, and eventually the river had been made navigable for small boats and rafts up as far as Wells

River, Vt.; and in 1797 the tolls amounted to about five thousand dollars.

The navigation works at South Hadley Falls, on the easterly shore of the river, and opposite the present city of Holyoke, were the property of the proprietors of the locks and canals on the Connecticut River. This company experienced the usual periods of depression and of business prosperity, until, in 1833, dividends of fifteen thousand dollars were paid; but soon after this the building of railroads cut into the business of the canal company, and in 1848 its stock was acquired by the Hadley Falls Company.

It was not until 1883, however, that the affairs of the old company were finally wound up. At that time a curious incident was brought out, showing the difference of business methods between the early days and the present. It became necessary to look up the stock of the old corporation, and for a long time only 503 shares could be found, yet there had originally been 504 shares, in 1792. A careful search of the records brought out the following entry:

"I, the within-named James Bull, of Hartford, in the state of Connecticut, in consideration of a valuable sum of money, viz., two hundred dollars (\$200), received to my full satisfaction of Jonathan Dwight, Esq., treasurer of the Lower Locks and Canals on Connecticut River, the receipt whereof I do hereby acknowledge, do assign and make over all my right and title to the within-named share, No. 80, and all privileges and rights to which I am entitled by virtue thereof, to him, the said Jonathan Dwight, Esq., or his successors in office, to have and to hold to him and to them, so long as the corporation shall remain a body politic.

"WITNESS my hand and seal this eleventh day of December, Anno Domini, 1807.

"JAMES BULL [Seal]"

"Signed, sealed, and delivered
in the presence of
THOMAS BULL,
CHARLES BULL."

That is to say, this good treasurer, instead of indulging in the modern amusement of stock-watering, had really started in to

condense it, and had commenced the movement by boiling down the stock to the extent of one share.

In regard to the first dam built by the Hadley Falls Company, a description published in 1853 states that it was at first contemplated to throw across the river a temporary dam, which, while it would serve as a protection to the erection of one more substantial below it, would answer the purpose of the company until such permanent dam should be completed. The first dam was accordingly built with less regard to strength than the result proved would have been prudent. It was not able to resist the force of the river, and was carried away after the gates were closed, the shutting of the gates having occurred earlier than had been designed in consequence of a freshet in the river.

Disastrous as this was, it is probable that it was really a fortunate thing that the dam went out, for at that time the coffer dam above the gate house was breaking up and the head-gates were not in their positions. Had that coffer dam given way and turned the whole river through the gates into the unfinished canals and over the site of the city, tremendous damage would have resulted — probably much greater than the loss of the lightly constructed timber dam.

An old drawing, purporting to be a plan of this dam, shows the slope of the back to be an angle of about 30 degrees to the horizontal. The sills were of timber 24 inches square and laid 6 feet on centers across the bottom of the river at right angles to the dam. The posts, 18 inches square, were framed into the sills and into the rafters, and were at right angles to the latter and 6 feet apart. The back of the dam was covered with 4-inch planking. All timbers and planks were of hemlock, about two million feet being required.

The company was hampered by labor troubles in January, 1848, a strike having occurred when wages were reduced from seventy-five cents to seventy cents per day, but as the year rolled around, the works of the company progressed through the labor of its 800 employees, so that on November 15 and 16 notices were published in the Springfield paper of the closing of the sluiceways, and at ten o'clock on the morning of November 16, 1848, the gates were closed in the presence of a crowd of 1 500

to 2 000 witnesses. When the water had risen within 2 or 3 feet of the top, all but about 75 feet at one end and 100 feet at the other rolled over, at 3.20 P.M., and went crashing down the river on the crest of a huge wave.

The loss to the company was about thirty-eight thousand dollars; but immediate steps were taken for the erection of another dam upon a very different and much stronger plan, and the work, which began in April, 1849, was carried to completion that same year, and still stands in the river in its original position. At the beginning, two coffer dams were built, one on each side of the river, each extending 200 feet from the bank into the stream. They were completed in May, the water pumped out, and the rock excavated to a depth of 6 feet. The construction of the main dam was then begun by laying down three 15-inch square sticks lengthwise across the river. The dam was started in sections, 6 feet from center to center, there being 170 sections. These sections were connected or tied to each other by 12-inch square sticks running across the river. The structure above the foundation sticks was made up of alternate courses of these ties and rafters, also 12 inches square. Between the rafters, in the same course with the ties, short blocks were introduced to stiffen or prevent the bending of the rafters. At splicings of the rafters long pieces were put in, treenailed to the rafters with eight 2-inch treenails of oak. The foot of each rafter was scribed and bolted to the rock with $1\frac{1}{4}$ -inch iron bolts. The structure was thus reared to its full height of about 30 feet, and its upstream face covered with 6-inch plank, with the exception of a space 16 feet wide by 18 feet long, which was temporarily left open. The toe of the dam was secured by a second covering of plank at right angles with the first, with the lower end scribed and bolted to the rock. Four feet of the crest of the dam on the upstream side were covered with boiler iron $\frac{3}{8}$ -inch thick, for protection from ice and driftwood.

In this manner, 400 feet of the dam were completed, 200 feet on each side of the river. As the summer advanced, another section of 200 feet was added to each side, leaving but 217 feet open for the water to run through. A coffer dam was then built covering this space of 217 feet, and the water of the river allowed

to run through the spaces left for the purpose in the four previously constructed sections.

After the completion of the middle section of the dam, the last coffer dam was removed, and preparations made to stop the temporary openings through the structure; this was done by gates hinged to the planking.

Four million feet of timber are contained in the structure. Gravel was filled in and well pounded down to the foot of the dam, which is still further protected by the addition of a mass of concrete.

As the timber work went up, the whole foundation, 90 feet in extent, and all open spaces were packed solidly with stone to the height of 10 perpendicular feet. The planking on the upper portion of the dam was laid to a thickness of 18 inches of solid timber (three layers of 6 inches each), all treenailed, spiked, and strongly bound together. The graveling in the bed of the river begins 70 feet above the dam, and is continued over 30 feet or more of its sloping surface.

During the construction of the dam, the water was allowed to flow through gates in it, 16 by 18 feet in size, of which there were 46 in all when the work was finished. At twenty-two minutes before one o'clock in the afternoon of October 22, 1849, the engineer gave a signal, and half of the gates were closed; another signal immediately followed and the remaining gates were closed; the river ceased its flow, until its waters, gradually collecting, rose upon the face of the dam, and finally fell in a broad sheet over its crest, about ten o'clock at night.

The chief engineer of the work was Philander Anderson, who entered West Point in 1827, but did not graduate. Mr. Anderson was a man of great ability, and his excellent plan for the canals and streets of the new city stands as a monument to his professional character.

The dam was destined to an early test of its strength, for November 12, 1849, brought a freshet of six feet over it, and the windows in Springfield are said to have been shaken at the rate of 128 vibrations per minute as the result of the sheet of water passing over without opportunity afforded for the free passage of air beneath. The following May there were $8\frac{1}{2}$ feet over the

dam; in 1854, $10\frac{1}{2}$ feet; and in April, 1862, $12\frac{1}{2}$ feet. The abutments had been planned for only 10 feet, so that it was necessary to raise them, and in 1877 the whole gate house was raised.

The dam is built upon a ledge of red sandstone, showing in some places a somewhat slaty structure. The ledge dips downstream at an angle of about thirty degrees to the horizontal, so that the water, as it fell over, struck the seams of the ledge in the best direction for splitting off layers of rock and sending them downstream. The effect of the constant perpendicular fall through thirty feet of such a body of water was to rapidly cut out such a ledge, and this, added to the action of ice and logs carried against the foot of the dam by the undertow, soon began to tell upon the parts of the work visible at times of low water.

In 1868, when the dam was nineteen years old, there were depressions in the line of the crest, and examinations made by men who crawled through the dam behind the sheet of water, revealed the fact that logs passing over the dam and then striking the face, end on, must have caught between the timbers, and acted the part of huge levers to break and pry out the face timbers. The ledge had also been washed out to a depth of 20 to 25 feet, and in some places had worked back far enough to undermine the dam. No time was to be lost, so during the years of 1868, 1869, and 1870, an apron was built downstream from the dam of 1849. The volume of this apron far exceeded that of the dam itself; it was constructed of round logs built up in perpendicular bins, cob-house style, and filled with stone before the covering was put on. The cost of the apron is not known exactly, but was probably not far from three hundred thousand dollars. Its effect was to prevent further injury to the timbers of the dam by ice and logs, and to stop any further undermining of the main dam; but it soon caused a new hole, 20 to 25 feet deep, to be scooped out of the ledge at its foot.

It had been expected by the designers of the dam that the leakage would keep all timbers constantly wet, and thus effectually prevent decay, and it was even proposed that if the plank covering did not leak sufficiently for this end, holes should be bored in it to give sufficient water. But these expectations were not realized; there was a gradual settling of the dam, until,

in 1875, there were parts of its crest a foot or more below the lawful level, as fixed by the original bench mark on the masonry. At that time a new crest was built, and the sloping faces of the dam and apron brought up to it by means of wedge-shaped timbers spiked upon them.

In 1879 troubles of another nature developed,—a whirlpool was seen on the surface of the water above the crest of the dam, and an examination showed a break in the plank covering. This, and other breaks like it, were repaired by means of cribs sunk to enclose the holes. These cribs were like boxes without top or bottom, — the underside being built to accommodate the slope of the dam, — floated out to place and weighted with stones, and the repair work was carried on within them.

Breaks occurred in 1881 and 1882, but in 1884 there was one more serious than any before, on account of its size and the amount of water that passed through it at the season of the year in which the supply to the mills is limited. A crib, 40 by 45 feet, was built and floated out, after it had been found that a 20 by 35 foot crib was too small, when it was found that the hole had again grown and was beyond the limits of the big crib, so that it was necessary to place another beside it. The combined cribs were sufficient to cover the hole that had grown to be 60 feet in length and 2 or 3 feet wide, through which water had been pouring under a head of 10 or 15 feet.

The experiences of 1884 convinced the officers of the company that heroic measures should be taken to prevent such breaks in the future, that the supply of water for the canals might be safeguarded and the safety of the dam assured.

In 1885 about twenty feet of the top surface was replanked, and a row of piling, not vertical, but at right angles to the slope of the covering, was placed inside and thoroughly gravel puddled, with the idea of making the structure water tight and of supporting the planking of the top so that it could not be forced downward by the weight of water upon it. These repairs were carried out in sections, by building coffer dams about one hundred feet long around sections of the dam.

Mr. Clemens Herschel, the engineer in charge of these repairs, in speaking of the lessons to be learned from such work, says:

“ First and foremost, a wooden dam should never be left hollow, nor should it be filled with stone. Let a row of sheet piling be put in, in some proper position, then puddle in gravel. Gravel is water-tight, or soon becomes so; stone filling is not. Gravel will protect every timber it encases from rot forever; stone filling will permit decay, and so will the moist, foul air to be found in the interior of all hollow dams. Worst of all is a dam entirely hollow.”

The filling of the dam with gravel had the desired effect in at least one direction for a number of years, for the leak was very small, but the dam was still settling, as was shown by careful levels taken upon its crest each year as opportunity was afforded by low water. In ten years this settlement amounted to about six inches average for the whole dam.

In 1893 and 1894 breaks occurred in the planking, and the leakage increased, all of which showed that the gravel no longer filled all the voids of the interior, and that the dam was threatened with the very trouble that the work of 1885 was expected to prevent.

In 1891 steps were taken for the erection of a stone dam, and surveys were begun that year, and a location chosen far enough downstream that only a small portion of the new structure should stand in the hole worn in the ledge at the foot of the apron.

The masonry dam is 1 020 feet long at the spillway, 30 feet high above bed-rock at the back, and 54 feet wide on the bottom. The back is stepped off 1 foot in 5 all the way to the top, as a batter, the steps affording footings for coffer dams during course of construction. The rear part of the top is beveled for a width of about 5 feet, beginning at a point 2 feet below the crest and running to a point on top 2 feet back from the center line. There is then a level space of 2 feet wide to the center line, and from there the face is an ogee curve, consisting first of a parabola and then an arc of a cycloid. The lowest point in the face, which is the vertex of the cycloid, is 30 feet vertically below the crest and 34.89 feet horizontally from the vertex of the parabola. The curve then rises from the lowest point to the toe, 7.33 feet beyond, and to a height of 0.98 foot, the intention of this rise being to prevent as far as possible the erosive action upon the river bed.

The body of the dam is of rubble, laid in Portland cement mortar. The spillway, upper face, and five feet of the top are of heavy granite blocks, those at the lower part of the spillway being fastened together with galvanized iron dogs, while those on top are secured with iron dowels.

There are over 48 000 cubic yards of masonry in the entire structure, divided as follows: 34 500 cubic yards rubble, 1 825 cubic yards dimension granite in the upper courses, 7 000 cubic yards granite in the face, 2 500 cubic yards granite in the back, and 2 300 cubic yards granite in the abutments and wing walls.

Three years were needed to complete the excavations in the river bed for the foundations, this work being done by the company by day labor. A trench was dug to an average depth of 8 feet, and from 15 to 18 feet wide, and the bottom was leveled off by a bed of concrete for the reception of the masonry. About 13 000 yards of slate and red sandstone were taken from the foundation trench, and, in order that the bottom could be drained during construction, another trench 600 feet long, 17 feet wide, and 10 feet deep was excavated, beginning near the center of the river and extending down stream.

The toe of the dam is protected from erosion and undermining by a heavy bed of rubble masonry, the greater part of which has been covered with concrete. The stone for the rubble was taken from the bed of the river, the greater part of the granite is from the quarries of Vinal Haven, Me., and the cement is known as the Alpha brand.

Five years were required in the building, no work being done during freezing weather nor during times when very great quantities of water were flowing over the wooden dam. But few heavy wooden coffer dams were employed, and these only when closing a gap; sand-bag dams were very largely used, and, when occasion required, were reinforced and raised to stand a pressure due to six or eight feet of head.

The specifications written for this work have been noted all over the country for the extra quality of the work which they require, and many a contractor has remarked that "it might do very well to put such things on paper, but that no one would furnish material exactly fulfilling the requirements." But the

material and the workmanship both are up to the requirements, and the dam stands to-day as an example of one of the finest pieces of that kind of work to be found in this country.

The system of distributing canals is laid out on the nearly level plain inclosed by the bend of the river, and consists of three levels, the fall between the first and second being 20 feet; between the second and third, 12 feet; and from the third to the river, 24 feet when there is no backwater. Those mills situated on the first level and discharging water to the river have a head varying from 32 to 40 feet, depending upon the location; and the fall from the second level to the river varies from 20 to 32 feet.

The head-gates in the bulkhead are operated by belts and gearing driven by a turbine in the basement. The first level canal immediately below the bulkhead is 140 feet wide and 22 feet deep; after the first 1 000 feet of its length, the width of canal diminishes at the rate of 1 foot in a hundred, and its depth 1 foot in a thousand.

The area of section of the second and third level canals is not so great as of the first, but yet of such a size that a velocity of two feet per second is seldom if ever exceeded at any point throughout their entire length. Careful watch is kept upon the level of the water in all canals, more or less being admitted from the river or canal above, in order to maintain as nearly as possible a constant level, no matter what quantity may be in use. Waste weirs and gates are provided on all canals for the purpose of regulation. The watchmen at these stations have ready means of communication by telephones and signal bells.

The mill corporations hold their power under a form of lease or grant that is especially interesting, as it is perpetual, and is put on the county records in the same way as any other deed. Every grant of power carries with it the land necessary for the mill buildings, and the price is based only upon the amount of power, and not upon the amount of land conveyed.

In many of the older grants, covering what is now known as permanent power, the consideration was a lump sum, sometimes called a bonus, of \$5 000 per mill-power and an annual rental of \$300 or of \$450 forever, according as the power granted was for

sixteen or twenty-four hours. Many changes were made from time to time in the bonus as well as in the rentals, and at the present time permanent power would demand a much higher price than that realized fifty years ago.

The term "mill-power" just used in speaking of the rentals was derived as follows: "The second mill built at Waltham contained 3 584 spindles, with all the apparatus necessary to spin No. 14 yarn and convert it into cloth, which was taken as a standard, and the necessary water-power estimated and established as the right to draw 25 cubic feet per second on a fall of 30 feet, or a gross horse-power of 85.05, supposed to net about 60 horse-power."

As the original intention of the Hadley Falls Company was to build a city devoted almost entirely to the manufacture of cotton, it was but natural that the power unit in general use among New England manufacturers should be adopted here, and it was adopted with very slight change, and carefully defined in Article II of the proposals, which I now quote:

"Each mill-power at the respective falls is declared to be the right, during sixteen hours in a day, to draw from the nearest canal or water course of the grantors, and through the land to be granted, 38 cubic feet of water per second at the upper fall, when the head and fall there is 20 feet, or a quantity inversely proportionate to the height at other falls. And in order to prevent disputes as to the power of each mill privilege in the variations of the height of the water from changes of the seasons or other causes, it is understood and declared that the quantity of water shall be increased in proportion to the reduction of the height, one foot being allowed and deducted from the height of the actual head and fall, and also from that with which it is compared, before computing the proportion between them. Thus on a head and fall of 32 feet, the quantity of water used would be 23 cubic feet and to be $\frac{9}{31}$ parts of a cubic foot per second. And the respective parties, where either has any lawful interest therein, may, at all reasonable times, in a peaceable manner, and after due notice to the principal steward or agent then on duty at any mill, enter the raceway thereof to measure and compare the quantity of water used with the quantity granted, and in the measurements

all wastage shall be included,—and may also adopt and use such other mode of making or verifying the said measurement as the circumstances of each particular case may require.”

Articles III and IV declare that the grantors must forever keep in good repair the principal canals, and must forever maintain a dam across the Connecticut River, of such length and height as may be necessary to turn the water into the canals, also that the flumes and raceways are the property of the respective grantees, to be built and maintained by them in good repair.

Article V reads: “In order to continue in the grantors an interest in common with the grantees for the preservation and support of the mill-powers which may be granted, and to secure a fund to indemnify the grantees for expenses which may be incurred by them for making repairs, if the grantors should improperly neglect to make them, it is proposed that part of the consideration of every sale, and all that is to be allowed the grantors for repairs, etc., by them assumed, should be paid or secured to them in the form of a reservation of rent. It is therefore declared that each mill-power, with the land to which it is annexed, shall forever be subject to a perpetual annual rent of at least 260 ounces, troy weight, of silver of the present (1859) standard fineness of the silver coin of the United States, or an equivalent in gold, at the option of the grantee at the time of payment; which rent is to be paid in yearly payments forever, free from all charges or deductions whatever for taxes or assessments of every description which may be assessed or levied upon any granted premises after the making of the deed, all of which are assumed by the grantees. And a perpetual annual rent, at least equal to the above, shall be reserved for every mill-power hereafter sold.”

Up to the year 1880 no attempt had been made by the company to measure the water taken by any of the mills, although it was well known that some of the lessees were drawing quantities far beyond their legal rights, and thus inflicting an injury in times of low water upon such as drew no water beyond the amount held under lease. At that time steps were taken to make measurements and estimates of the quantities drawn by each mill, and a set of rules and regulations was formulated for the

draft of surplus. It was readily seen from the great number of turbines in use, and the widely diversified conditions under which they were used, that frequent or daily measurements in the flumes or raceways of the actual quantities drawn would be a cumbersome and expensive method; so it was determined to make each turbine a sort of water meter to measure its own discharge. With that end in view, the apparatus and machinery of the testing flume, then belonging to the late James Emerson, was bought, and later a much larger flume was built, in which is tested every wheel destined to draw water from the canals. The experiments are made to cover all conditions of load and speed likely to be found in its actual work, and from the results a chart is made up for the wheel, which, taken in connection with indicators placed upon the wheel in the mill, forms a basis for estimating the discharge at any time a reading of the indicators may be taken.

"Surplus power," which is offered for sale to owners of the so-called permanent power, so long as the river will furnish it, is sold at a daily rate, and charged for only when used — the present rate per mill-power for a twelve-hour day or night being \$2.50 net.

In addition to the permanent and surplus power already named, there has been sold certain power designated as "non-permanent power," which is not guaranteed, but will be furnished when there is more than a sufficient quantity in the river to supply all the permanent power, together with fifty per cent. of it as surplus. The rate of charge for non-permanent power is a bonus of \$4 500 per mill-power and an annual rental of \$1 500, with a rebate of the entire rent during times of non-supply.

Whatever influence the practice of manufacturers in the first part of the last century of using overshot and breast wheels may have had on the minds of the men who laid out the Holyoke system of canals and divided the fall into three parts, each of very moderate extent, it is certain that no motors except turbines have ever been employed here. Thirty years ago the main drivers of nearly all the mills were wheels of the Forneyron type, usually called Boyden turbines from certain improvements introduced by Uriah Boyden, a hydraulic engineer of Boston. These Boyden turbines have been gradually replaced by more efficient and

much more powerful wheels, mainly of local manufacture, so that only 14 out of the total of 160 turbines now on the Holyoke canals are of that pattern.

It is very interesting to note the development of the modern turbine, its gradual increase in speed and capacity, from the earlier types of the inward or outward flow wheels, with simple vanes, to the present form, whose compound curves are the despair of any mathematician who tries to analyze them. The development has been largely through practical experiments, rather than by abstruse reasoning, and the water power at Holyoke has played no small part in this development, for in its flume have been tested turbines from all the wheel manufacturers of note throughout the whole country; and each of the principal wheels now on the market embodies some of the curves and combinations that have been tried out by some patient experimenter at the flume, and in some directions Holyoke is better known as the location of the testing flume than as a manufacturing center.

The effect upon the community of the development of this great power has been wonderful — incorporated as a city in 1873, having had the dignity of a town for only twenty-three years. When the dam was sixteen years old, the population numbered 5 600, and the valuation was about \$3 000 000. Thirty-three years later, or when the dam still lacked a year of being a half century old, the population had increased 696 per cent., and the valuation 1 064 per cent. Boom towns of the West can scarcely show better records of growth in numbers and wealth and solidity of industries.

This may be called the age of electricity, but it is well to remember that no commercial current is sent out without the burning of some fuel or the application of the power of falling water.

DISCUSSION.

PRESIDENT E. C. BROOKS. I am sure you have all listened with a great deal of pleasure to Mr. Sickman's very interesting paper, which is now open for discussion. I know that Mr. Sickman will be glad to answer any questions which may be asked.

A MEMBER. I should like to ask what the average cost to the mills is for horse-power per year.

MR. SICKMAN. The cost of surplus power, which is the power that we furnish when we have it to spare, is about twenty-three dollars per year per horse-power. That is the most expensive power we have. The rate paid for permanent power is something below five dollars per year, but it must be remembered that the annual rental of that permanent power expresses only a part of its cost, because for each mill-power, when it was bought, a cash bonus was paid down, so that the price per horse-power is really involved, and it is not possible to give an exact figure for it.

A MEMBER. I should like to ask if rental is collected now in silver.

MR. SICKMAN. During the time of the depreciation of the currency during the war, we accepted greenbacks, and ever since the mills have always paid in currency. We have disregarded the silver clause in every instance except one. We never had but one mill which offered silver bullion, and yet it is stated in nearly all the leases made prior to 1880 that they have the right to pay the rental in silver bullion, but they have not taken advantage of it. If any engineers would like to see the dam, we would be glad to have them; and it is a good time now to see the construction of the dam, because there is no water running over it. The pond is drawn below the crest of the dam, and it is possible to see the entire masonry in front, and it is a very interesting sight.

MUNICIPAL WATER SUPPLY REVENUE.

BY JAMES L. TIGHE, CITY ENGINEER, HOLYOKE, MASS.

[Read September 14, 1904.]

The tendency of the present time is toward the greater extension of municipal functions by the ownership of all local public or quasi-public works, such as water works, gas and electric light works, etc.

These works are generally valuable assets and are, in most cases, not only self-sustaining, but, in many communities, contribute largely to the support of the municipality. As evidence of this, in Great Britain, some years ago, many municipal debts were increasing so rapidly that it was feared local taxation would eventually become too burdensome. These debts, however, cause at present no alarm to the taxpayer on account of their being partly met or provided for by revenue made available through municipal ownership. In other words, the burden of the taxpayer is greatly lightened by the profits made on public enterprises owned and operated by the municipality.

While this method of raising revenue through municipal ownership of public works for defraying or helping to defray the expenses of government is quite popular in Great Britain and other countries, and becoming popular in this country, yet, is such a method of meeting the expenses of government just and equitable to all, that is, to the community at large living within the municipality?

This is the proposition the writer proposes to discuss, and, in order to be as brief as possible, he will discuss only the equity of using in this manner public water supply revenue.

The first maxim of taxation, as laid down by Adam Smith, generally called the father of political economy, and accepted by almost all political economists and writers of that science since then, is that "the subjects of every state ought to contribute toward the support of the government as nearly as possible in proportion to their respective abilities; that is, in proportion to the revenue which they respectively enjoy under the protection of the state."

This maxim or canon is not only applicable to the government of nations but also to the smaller communities in which any form of government whatever exists, whether in county, town or municipality.

Since, then, every community should contribute sufficient revenue to support the government formed for its protection and enjoyment, it should be the aim of that government to collect this revenue proportionately equal from each member in accordance with his ability to contribute.

It is in the observance or neglect of this principle that the equality or inequality of taxation exists. It is in the observance or neglect of this principle that taxation, in any form whatever, is looked upon by all as a perfectly legitimate obligation that each individual is bound to meet, or as an arbitrary extortion collected under protest from those on whom the greater burden is imposed.

Now, for instance, in our local governments, is the above maxim fulfilled when water supply revenue is arbitrarily used in defraying or in helping to defray the expenses of the government? It certainly is not, and any water supply revenue, no matter how little used in this manner for such purposes, is not only taking a legitimate burden off one class of the community and illegitimately placing it upon another, but is doing it so disproportionately that those least able to carry it are burdened the most.

As an illustration, suppose the revenue of the water supply system was sufficient in itself to support the municipality; then the water purchasers who contributed this revenue would be the sole support of the municipality, while all others, such as those holding personal property and large landed interests kept, for instance, for speculative purposes, would not be contributing a single cent. And the same reasoning applies whether the revenue collected from the water tax is sufficient to support the municipality or a small fractional part thereof.

For instance, let the total amount of the expenses of the municipality be \$1 000 000, and of this amount \$50 000 are contributed from the water supply revenue, thus leaving \$950 000 to be contributed by regular taxation. What would this mean? Simply that instead of levying a tax to raise \$1 000 000 from all taxpayers, a tax would be levied to raise only \$950 000, the remaining

\$50 000 to be contributed by the water purchasers in the form of a second tax concealed in the water rates under the guise of water rents.

Of course the point might be raised that the water takers and the taxpayers are practically one and the same. Admitting this and assuming again that the municipality was supported wholly by revenue from the water supply, would the contributions then toward this revenue be proportionately equal from all? Certainly not, for the owner of a tenement block, worth, perhaps, fifteen thousand dollars, would be probably contributing more than five times as much as the owner of a private mansion worth fifty thousand dollars, or the owner of a large factory worth five hundred thousand dollars.

In illustration of this, actual figures taken from the books of the city of Holyoke will be used, which will more clearly demonstrate those points than any kind of reasoning whatever.

There were in 1903, in Holyoke, 3 576 taxpayers who paid taxes on property, real and personal. Of this number there were 2 338 who paid taxes for water.

The revenue required to run the city in 1903 was, in round numbers, \$1 240 000. Now if this revenue was all raised by the sale of water, the 2 338 water purchasers, who contributed toward the treasury of the public water supply, would be supporting the city, while owners of real estate and personal property, to the number of 1 238, would be contributing nothing at all toward its support. And besides, not only this, but the city would be supported by revenue contributed so disproportionately that, for example, according to the records of 1903, the largest corporation taxpayer would contribute only one-seventh as much as the largest individual taxpayer per dollar of valuation.

Of course, the defraying of the total expenses of a municipality by revenue raised in this manner would be an extreme case, and, it may be said, would never actually occur.

Let us then take a case that may occur and does occur in many municipalities and towns, viz., where all the revenue contributed by the water purchasers beyond what is barely needed for maintenance is yearly appropriated by the government for its support. Let us assume, in Holyoke, for instance, that this amount was in

1903 thirty thousand dollars. Referring again to the records of the city, it can be seen that the second highest corporation taxpayer would be contributing only one one hundred and thirtieth ($\frac{1}{130}$) as much toward this thirty thousand dollars as would the second highest individual taxpayer per dollar of valuation. In other words, the individual taxpayer would be contributing one hundred and thirty times as much as the large corporation toward the construction and maintenance of streets, bridges, etc. That is, the heaviest burden would be placed upon the one the least able to carry it.

Would this be just or would it agree with the first maxim of taxation as laid down above, which says that all subjects ought to contribute toward the support of the government as nearly as possible in proportion to their respective abilities?

The answer is plain, as the inequality of such a scheme for raising revenue to help to defray the expenses of municipal government equals, if not surpasses, that famous or rather infamous tax in vogue in England in the eighteenth century, known as the window tax, by which the inhabitant of a house worth one thousand dollars, situated in a backward country village, had to contribute more toward the support of the government than the inhabitant of a house worth fifty thousand dollars in Regent Street, London, simply because the former had more windows in it than the latter.

Another burden that the water purchaser has to carry is the extra expense incurred in providing larger mains for fire protection, the furnishing of water free for fire purposes, and for all municipal uses, and the setting of fire hydrants, etc., all of which should be borne by the regular taxpayer.

The conclusion, then, to be drawn from this discussion, is that it is not equitable or just to raise revenue in this manner for defraying or helping to defray the expenses of government.

If this conclusion is correct, then, on the other hand, referring again to the first maxim of taxation, "the subjects of every state ought to contribute toward the support of the government as nearly as possible in proportion to the revenue which they enjoy under the protection of the state," the question may be asked: What support would the public water supply contribute

toward the government which protects it and under which it enjoys its revenue? No support whatever, but, instead, would be a burden upon the taxpayer because of the special immunity granted it, which exempts it from any obligations toward the support of the municipality. Through this it is an indirect burden upon the taxpayer.

Suppose, for instance, the public water supply belonged to a private corporation, and that this corporation, like other private corporations, would be subject to taxation, and had to contribute toward the support of the government, the amount thus contributed would lighten the burden by so much on the taxpayer. On the other hand, if not so contributed, it would be collected from the general taxpayer by the levying of a higher tax rate.

As an illustration, suppose the expenses of the municipality, for any one year, were \$1 000 000, and that the private corporation owning the public water supply contributed in taxes toward this amount \$20 000, the remaining taxpayers would be called upon to contribute only \$980 000; whereas, if the private corporation was not called upon for a contribution the total amount of \$1 000 000 would have to be contributed by the remaining taxpayers, thus placing a greater burden upon them to the amount of \$20 000.

And is not this what occurs when no revenue is contributed toward the support of the municipality from the municipal water supply treasury? Hence, why is it that the municipal water supply, exempt from taxation, or all government obligations, so to speak, is a burden to the taxpayer?

But it has been demonstrated that any revenue taken arbitrarily from the water supply treasury and contributed toward the support of the municipality would be an injustice to the water purchaser, while now it is demonstrated that if revenue is not contributed from the public water supply treasury toward the support of the municipality an injustice is done the taxpayer.

Thus it appears as if the proposition was reduced to an absurdity.

However, this is not the case, for it must be borne in mind that the discussion on the first part of the proposition is based upon the hypothesis that the water supply revenue was arbitrarily appro-

propriated by the municipality regardless of the amount, as is usually the case.

In order, therefore, that equity might be established between taxpayer and water purchaser, some system or method should be adopted that would do justice to both.

It seems that the plan or policy to adopt would be the imposing of a tax upon the water works the same as if it belonged to a private corporation.

The writer knows of no municipality where this has been systematically done except in the city of Holyoke. Here by special act of the legislature, the water works are assessed in the same manner as all private property, except that the valuation of the works is not left to the discretion of the government, but is based on the total cost of the construction of the works less the depreciation, as stated in the report of the water commissioners of the previous year.

The idea of using the cost of construction taken from the records as the valuation of the works was adopted upon the principle that the amount of the tax to be paid should in no sense be arbitrary, but certain, and known as nearly as possible ahead of time so as to enable the water commission at all times to govern their expenditures.

The idea was also adopted in order to prevent the government from increasing unduly the valuation of the works, a thing which might never be attempted—yet what will governments not sometimes attempt, especially when large deficits have to be met?

The water works charges the municipality for all the water used by it in its various departments at the same rates charged private consumers. It also charges for fire hydrant service, which is so much per public hydrant per year, and is a fixed sum meant to cover only the first cost and maintenance of the hydrant.

Since this plan or policy was adopted and put into operation, which was in 1901, it has worked most satisfactorily to all concerned.

The principles upon which it was framed can, the writer believes, be recommended as a basis for the equitable adjustment of revenue raised, not only from the municipal water supply, but from all public utilities owned and operated by the municipality.

DISCUSSION.

MR. M. N. BAKER.* The plan outlined as adopted by the city of Holyoke seems to be unique in one particular, and has much to commend it in the other particulars as well. So far as I know this is the only instance in this country where a municipality has taxed its own property. It seems to me that the more important principle involved is that of making each department of the municipality pay for the water used, and while there is nothing new in that, it is not as frequently the case as it should be, as all people who are responsible for water works management know too well to their sorrow. It seems to me that possibly there might be a little difference of opinion as to the fundamental principles which should govern in adjusting these matters under discussion. The charges for a public water supply should be, I think, in accordance with the benefits received and not in accordance with the ability of the person who has to pay. I think there is a fundamental difference, and that we should not consider this as we do ordinary taxation for municipal purposes. Perhaps, however, the idea is correct in its application, so far as it relates to the assessing of water works for the purposes of general taxation.

MR. HUGH McLEAN. It seems to me, Mr. President, that Mr. Tighe's conclusion is the only proper solution of the problem of municipal ownership of public utilities, so far as the question of taxation is concerned. For instance, in the beginning, before Holyoke adopted a municipal water supply, private individuals owned the water works and the property was taxed and a revenue was turned into the city from that tax. When the city adopted municipal ownership that revenue was lost. The city has branched out and added to the works year after year, and in doing so has taken many dollars' worth of property from owners who were formerly taxed for that property, and the money they paid in taxes went into the city treasury. The city now receives some twenty-two thousand or twenty-three thousand dollars in taxes from her water department in consideration of the value of the property taken from individuals, upon which they formerly paid taxes, and the department is still able to sell water at a lower rate by one fifth than the previous owner of the water works did.

* Associate Editor, *Engineering News*, New York City.

I think with the advancing ideas as to public ownership of all quasi-public utilities, such as water and light plants, the proper policy is to apply a tax as the city of Holyoke has to her water department.

MR. GEORGE A. KING. As I understood Mr. Tighe, the tax is assessed upon the cost of the works. It seems to me that that is not in accordance with the well-recognized principle that the assessment must be based upon the actual market value.

ADDITIONAL WATER SUPPLY FOR NEW YORK CITY.

BY RUDOLPH HERING, CONSULTING ENGINEER, NEW YORK, N. Y.

[Read September 14, 1904.]

About five years ago it became apparent that the sources of water supply, then supplying Greater New York to the extent of about 370 000 000 gallons daily, would soon be exhausted, and during a drought much inconvenience would ensue. As it would take five or six years to build works for an additional supply, the time for selecting new sources was therefore close at hand.

A private company, known as the Ramapo Water Company, thereupon offered to enter into a contract to supply the city of New York with 200 000 000 gallons of water daily from the Catskill Mountains for a term of forty years, at a fixed rate of seventy-nine dollars per million gallons, — the approximate cost of the water then supplied by the city being less than half this sum.

As there was much doubt regarding the wisdom of entering into such a contract, the city comptroller, Mr. B. S. Coler, in 1899 caused an investigation to be made into the present water sources of the city, their sufficiency in the near future, the best means of increasing the supply and the advantages and disadvantages of the Catskill sources which were proposed and controlled by the Ramapo Company. The Merchants' Association of New York, some four months later, and through a special committee on water supply, began a similar investigation. Its inquiry was directed toward the conditions relating to the present and future supplies for the city by committees on engineering, legislation, municipal finance, and public policy.

These two efforts resulted in the issue of two valuable reports in the summer of 1900. The first of them concluded that the present supply of Manhattan and the Bronx, with prudent management, would be ample until 1905, and recommended immediate steps for taking an additional supply of 150 000 000 gallons daily at once, and later 500 000 000 gallons daily, from the Ten-Mile and



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Housatonic rivers in Connecticut, at a cost of about fifteen dollars per million gallons. The other report, in view of prospective legal difficulties in utilizing the waters of adjoining states, recommended that an additional supply be taken from the Hudson River at a cost of about twenty-nine dollars per million gallons. It found that the boroughs of Brooklyn, Queens, Richmond, and the Bronx needed an increase of water supply at once, and Manhattan in less than ten years. Other than the conclusion regarding what was believed to be the most available source, the two reports did not differ materially as to amounts of water obtained from the several possible sources and the cost of bringing them to the city. Both reports were based, however, merely on a few months' reconnoissance of the territory with the aid of existing maps, and founded on such limited legal and other investigations as time and funds permitted. They recommended that thorough surveys be made of the best sources that the reconnoissance had revealed, and had for their main purpose the clearing up of the chief questions concerning the water supply, so that all practicable sources for the future could be laid before the community, together with an estimate of their costs, and so that those projects could be pointed out which were most promising, as well as those which were impracticable. Plate I is a general map of the sources investigated.

About a year after these reports had been made, surveys were begun by the city, but were limited to a storage basin in the lower part of the Esopus watershed. In November, 1902, however, Mayor Low appointed a commission of engineers* to make thorough surveys of the entire field for obtaining an additional water supply, and this commission made its report last December. It was greatly aided by the work that had been done during the three preceding years; otherwise it could not have completed its work in so short a time.

The boroughs of Manhattan and the Bronx are supplied almost entirely from the Croton watershed, having a drainage area of about 360 square miles, a small amount being supplied from the 22

* William H. Burr, Rudolph Hering, and John R. Freeman. The Department Engineers under this commission were E. G. Hopson, aqueducts; Walter H. Sears, Catskills; William B. Fuller, filtration; Geo. C. Whipple, chemical and bacterial work; W. E. Spear, Long Island ground water; Will J. Sando, pumping.

square miles of the Bronx and Byram watersheds. When the new Croton dam is completed, the total available storage capacity of the Croton watershed will be about 75 000 000 000 gallons. The present draft from this supply is at the rate of about 275 000 000 gallons per day, and about 13 000 000 gallons daily are drawn from the Bronx and Byram supplies. Two aqueducts are now available for conveying water to the city. The old Croton aqueduct has a capacity of 80 000 000 gallons per day, and the new one 300 000 000 gallons per day. The former can, however, scarcely be considered available at the present time except as a resort in case of emergency.

The last three years have been phenomenally wet, and the dangerous shortage of the water supply of New York City has thereby been obscured. If the city should experience one year, or particularly two years in succession, of drought such as occurred six and seven years ago, the capacity of the Croton watershed would now be almost exhausted, unless the waste and the consumption were restricted.

The borough of Brooklyn procures its supply from the surface waters and ground waters of Long Island to the extent of over 100 000 000 gallons daily. Some of the surface waters are rapidly becoming so polluted that they will not be safely available much longer, while others could be made safe by filtration. About one half of the supply is taken from shallow and deep wells penetrating the saturated sands underlying the surface of the southerly portion of Nassau County. The demands of Brooklyn have already practically exhausted the present supply, and additional works are being constructed for the purpose of increasing the supply of ground water.

The needs of the borough of Queens are probably more immediately pressing than are those of any other part of the metropolis. Its present supply is derived from ground water secured from wells driven within its limits, the yield being both insufficient in quantity and some of it not satisfactory in quality. It is imperative that its supply should be increased at the earliest practicable date.

The borough of Richmond is also in need of an improved supply, which it is not practicable to obtain within its own limits. Its

present supply is from driven wells, the yield of some of which is of poor quality, and in all of them insufficient in volume.

As regards the quantity of water required for the whole metropolis and for which present provision should be made, the last commission fixed on 500 000 000 gallons per day as a proper amount, which is little more than doubling the present supply. It decided also that proper connections should be made between all of the several boroughs so that a temporary deficiency in one locality could be immediately relieved from another.

As regards the quality of the water to be furnished, the commission took the advanced view that few, if any, public supplies of surface water are of a sufficiently high degree of excellence to obviate the necessity of purification. It therefore recommended the artificial filtration of all of the surface waters which would be needed, and, so far as practicable, the use of all available ground water or spring water, which is naturally filtered water. The only locality where the latter supply is practicable is Long Island, where large quantities of ground water are available.

At the outset the commission was instructed by the corporation counsel that for the purpose of avoiding interstate litigation and serious delays, the investigation should be confined to waters available within the state of New York. No further studies were therefore made of interstate streams such as Ten-Mile River, Housatonic or Walkill sources, which heretofore had been generally recognized as the most economical sources of supply for New York City.

The wide scope of the investigation to be undertaken made it necessary to appoint a large force of engineers, biologists, chemists, and others, and to divide the work practically into seven parts, as follows:

1. Present waste of water.
2. Pumping stations.
3. Chemical and biological work.
4. Supplies beyond the Croton.
5. Aqueducts and reservoirs.
6. Filtration.
7. Long Island supply.

WASTE OF WATER.

When the commission began its labors the Department of Water Supply, Gas and Electricity had already started upon a systematic investigation of the subject of water waste in typical districts by means of the pitometer, an instrument recently perfected and made convenient for practical use. The methods adopted received the hearty approval of the commission, and as such work was more conveniently conducted through the regular channels of the department, this subject was considered by the commission only in the results thus obtained.

It was obviously impossible within the time and means available to explore the main and service pipes and house plumbing throughout the entire city. Typical districts were therefore selected in different parts of the city. These comprised the principal hotel district, with a large transient population; two residential districts with houses of an expensive class; two East Side tenement-house districts; two large downtown commercial districts having a large day population but a small night population; and a few others of intermediate grades.

There were two distinct branches of inquiry, one along the street mains and the other along the house pipes, or plumbing. The first comprised a measurement of the quantity of water delivered daily into each district and observations of its rate of draft continuously, day and night, so that the mean rate of flow in working hours could be compared with that of the quietest hour of the night, and also on Sunday. The second inquiry comprised an inspection and search for leaky plumbing fixtures in each house of the district, including a measurement of the rate of each leak where possible.

The measurements were supplemented by an examination of the rate of flow after midnight in the sewers of the district, in the course of which the spur from every building was inspected for signs of leakage, so far as practicable. The inspector reported that the night sewer flow in most sections was surprisingly small, indicating that the night consumption of water was largely due to the refilling of tanks on buildings.

Unfortunately, peculiar conditions did not permit the district measurements to be made as elaborately in detail as has been

found practicable in other cities. It was not practicable to shut down the pipes as completely as necessary, as damage might be caused in various ways. There is also a universal absence of curb stop cocks on the service pipes of the buildings, so that they could not be shut off along the street after midnight. The extensive use of large house tanks interfered with the interpretations of the measurements. The absence of ball cocks on the feed pipes on many house tanks permitted them to overflow in amounts which it was difficult to estimate.

Notwithstanding these limitations, a large amount of valuable information has been secured.

The leakage from the mains was found to be much less than heretofore supposed. The main sources of waste are probably leaky plumbing fixtures, the overflow of tanks not provided with ball cocks, defective plumbing design, and abandoned service pipes.

The reduction of this waste can be effectively aided by the use of meters, which tend to make each householder an inspector of leaks, thus bringing prompt remedy for all obvious waste from leaky fixtures. The commission strongly recommended that the use of meters be extended to other classes of buildings than those now metered, particularly to the large modern apartment houses.

The investigation also demonstrated the necessity of considering the great transient population of the city in accounting for the per capita consumption. It was estimated that about 600 000 people enter Manhattan daily, and that while the per capita use and waste of Manhattan is 129 gallons per day if based on the resident population, it becomes only 100 gallons per day, a far more reasonable amount, if based on the combined resident and non-resident population.

In some districts the differences were still greater. In the resident and hotel district of Manhattan the daily per capita consumption was found to be 175 gallons, based upon the resident population, and 121 gallons when based upon the combined population. In the entire territory below Fulton Street, filled with office and commercial establishments, the per capita consumption was 860 gallons per day when based upon the resident population, and only 83 gallons per day when based upon the combined population.

By such discriminations a much more correct appreciation is obtained regarding the use and waste of water, and the latter has not been found to be so great as has been supposed in some quarters. Nevertheless, it is possible and practicable by the extension of the use of meters to save a large proportion of the water now wasted.

PUMPING STATIONS.

A useful part of the investigation made last year related to the examination of the existing pumping stations, resulting in recommendations which would materially improve the operation and save a large sum of money which is now annually spent for the pumping of water.

Although the Croton, Bronx, and Byram supplies are by gravity, about 20 per cent. of this water is now pumped to supply buildings on high ground. All of the water used in Queens borough and Brooklyn must be pumped. Greater New York maintains 32 pumping stations, with 86 pumps, lifting about 160 000 000 gallons daily, or over two fifths of the whole supply. There are about 400 men on the pumping station pay rolls, and about 75 000 tons of coal are burned annually.

The examination showed that while some of this pumping work was done well, much was not done efficiently. Detailed investigations were being made by the chief engineers of the boroughs, which, together with the commission's investigation as to improvement in the machinery, indicated that in the operating expenses annually about \$50 000 could be saved in the boroughs of Manhattan and Queens; and in Brooklyn, by using electric motors for the numerous low-lift well plants, to be operated from a central station, it was estimated that about \$90 000 per annum could be saved. Other economies at Gravesend, New Utrecht, Milburn, and Richmond, by consolidating the Mt. Prospect station with the Ridgewood station, as proposed by the chief engineer of the borough, would result in a further saving of over \$100 000 per year.

CHEMICAL AND BIOLOGICAL WORK.

This branch of the work was organized early, for the purpose of collecting samples of the winter and spring flood waters in all

the streams that might be available for the proposed additional supply. The work was conducted chiefly at the Mt. Prospect laboratory, Brooklyn, and at a field laboratory located at Poughkeepsie. This department made such chemical and biological analyses and such other investigations and inspections as were necessary to determine the sanitary quality and general fitness of all of the sources which the commission found available, and made a comparison of these various waters with the present water supply of the city. Its work included important investigations on the phenomena of capillarity, percolation, and soil moisture, chiefly with reference to studies of the ground water of Long Island.

The territory covered by these investigations comprised the western two thirds of Long Island, and extended along the Hudson River to the head waters of its upper tributaries. Occasional samples were also taken from the Housatonic, Ten-Mile, Walkill, and other streams for comparison. The entire territory covered was more than 15 000 square miles. Between January 1 and October 31 more than 9 000 samples of water were examined at Poughkeepsie, and 5 700 at the Mt. Prospect laboratory.

Among the more interesting results found by this department was the fact that a comparison of the rainfall and stream flow observations showed that typhoid fever is most frequent in dry years, when the reservoirs are most heavily drawn upon, and that with an increased storage capacity on the watersheds there has been a tendency for typhoid death-rates to diminish.

The analyses have shown that the ground water supplies of Long Island are substantially free from pollution dangerous to health, or, in other words, the natural filtration which these waters receive in their passage through the ground purifies them so that they are safe, notwithstanding that considerable sources of pollution lie in their path. Bacteriological and microscopical examinations were made of all the waters, and have given much information to aid judgment in selecting and treating the same for domestic supplies.

Physical examinations were made, relating to temperature, turbidity, color, and odor.

Chemical analyses assisted in this work by indicating previous

pollution by an excess of chlorine, or by the amount and character of nitrogenous matter present, and also in determining the hardness of the water and its effect when used in steam boilers.

Among the qualities which were recorded as essential for the new water supply, the following were deemed most important:

1. Freedom from pollution or from organisms capable of producing disease or discomfort.
2. Freedom from odor, or from noticeable turbidity or color.
3. Softness.
4. Freedom from iron in solution.
5. Freedom from substances liable to corrode metal work, either in boilers or in service pipes.
6. A cool and equable temperature, if practicable.

Careful investigations were made of the waters regarding these qualities, and the final recommendations kept them in view so far as practicable.

Thirty-four stations were established along streams for making sanitary observations, to secure representative samples, and inspection tours were made over the drainage areas to determine the sources of pollution, the character of vegetation, the extent of cultivation of the land, the appearance of the banks of the streams, and the general topographical and geological features. The completeness of these investigations varied with the probability of the water being used. A sanitary survey was made of the drainage areas of the Fishkill Creek, Wappinger, Roeliff Jansen Kill, the Esopus, Catskill, Schoharie, and Rondout creeks, to secure reliable data concerning the number of transient population along these streams, the number and size of summer hotels, the character of the villages, and their method of sewage disposal. Inspectors counted the houses and located them on maps, and estimated the number of summer boarders. Sources of pollution were, of course, noted and located.

The question of filtering the Hudson River water near Poughkeepsie required a careful study of the tributaries above that point. The Adirondack streams were free from pollution, conspicuously free from turbidity, even during spring freshets, and were very soft. But the water is about twice as dark as the

Croton water, due to the presence on the watershed of many swamps. The Battenkill, the Hoosac and Mohawk rivers were found to be polluted, and their waters hard and at times turbid. The Walkill was found to be decidedly hard and discolored by the extensive swamps and peat deposits of the so-called "Drowned Lands." The Esopus and Rondout creeks were found most attractive in quality by reason of their extreme softness. The drainage areas of all these mountain streams are sparsely populated, and although they contain many summer hotels and cottages these can be made unobjectionable from a sanitary standpoint by a comparatively small expenditure for sewage disposal plants in these villages and summer colonies.

The drainage areas east of the Hudson are also sparsely populated, but their water is about two and a half times as hard as that of the Croton, while the Esopus, Rondout, and Schoharie creeks have water twice as soft as the Croton.

The Hudson River water was made the subject of very full studies. The averages of many analyses show that the quality of this water near the proposed intake would be about the same as that taken between Albany and Troy, and that it can be made at least equally satisfactory by filtration. It was found that the additional pollution which the river receives at Albany is more than offset by the dilution from the volumes of water entering from the tributaries below. The commission expressed the opinion that with proper precautions the water taken from the Hudson River near Hyde Park can, by means of filtration, be rendered entirely palatable and safe for drinking, domestic, and industrial purposes.

With the view to locating the proposed pumping station on the Hudson River at a distance above the point to which the tide might carry salt water, under extreme conditions of drought and wind, an extended series of observations was made. Automatic tide gages were located at Yonkers, Oscawanna, West Point, Poughkeepsie, and Rhinebeck. From a review of all the records and examinations it appeared that a location near Hyde Park could be made safe. But during the season of extremely low rainfall, like that of 1883 or 1891, and in order to prevent at such times the salt water from rising up above Poughkeepsie, storage

reservoirs in the Adirondacks would be required to augment the low summer flow, and thus keep down the salt water. Such reservoirs incidentally would increase the summer flow of the upper streams and increase their natural water power.

SUPPLIES BEYOND THE CROTON.

As already stated, the waters from the Esopus and Rondout creeks in the Catskill Mountains were the best in quality of all the small streams investigated. They are unusually soft, and contain as little pollution as is usual in such streams. Whatever turbidity occasionally appears in them after heavy storms was found to arise from clay banks, which can readily be eliminated by protecting them against erosion.

On the Esopus Creek, at the point called Olive Bridge, about 13 miles west of Kingston, there is an excellent dam site for a larger reservoir than ever yet has been constructed for storage purposes in connection with municipal water supply. This reservoir as planned has an area of nearly 6 000 acres, or about $9\frac{1}{4}$ square miles, and the elevation of its high water surface is 560 feet above tide water. Its capacity is 65 000 000 000 gallons, or nearly as great as that of all the Croton reservoirs combined.

This watershed is characterized by extensive, steep mountain slopes, with wooded areas of such character that it gives a large yield of good water. It was found that it could be counted upon as yielding 250 000 000 gallons per day. On the east side of the Hudson River the three drainage areas investigated, namely, Fishkill, Wappinger, and Roeliff Jansen Kill, were capable of yielding about the same quantity of water, giving a total supply of about 500 000 000 gallons per day. Instead of using the Jansen Kill, the water of which is somewhat hard, it would be preferable to substitute the soft waters of Rondout Creek.

The commission suggested that the Esopus Creek waters should be brought down directly to Stormville as soon as practicable after the completion of the main aqueduct between Stormville and New York City. It was recognized that the waters of the Fishkill would be the least expensive to be secured by the city, but as they are somewhat harder than those of the Croton supply, the commission recommended that the large reservoir

for the Esopus water should at once be constructed, so that this soft water, by mingling with the waters of the Fishkill and Wappinger creeks, would leave a desirable softness to the mixture.

AQUEDUCTS AND RESERVOIRS.

Careful studies were made to show the best routes along which aqueducts could bring the waters from north of the Croton basin to the city. After careful consideration it was determined to build a single aqueduct of a capacity of 500 000 000 gallons per day rather than to build two smaller ones. The aqueduct was given the usual shape, with the greatest width near the bottom. The interior vertical diameter was made 18 feet 6 inches, and the maximum width 19 feet, at about one quarter the height from the bottom.

In studying the various lines and purposes of supply it was also determined that the next aqueduct to be built should be at a high elevation, discharging into a reservoir near the northern city line which was called the Hill View reservoir, at an elevation of about three hundred feet above the Hudson River. This aqueduct would supply all the high level districts to which water now must be raised by pumps.

It would require a tunnel nearly nine miles in length, which it would take four or five years to build. This tunnel would be necessary for all sources beyond that of the Croton.

FILTRATION.

The advance of knowledge in the filtration of public water supplies, the experience now available regarding the efficient and economical methods of such filtration, and the late demonstrations of the sanitary value of properly filtered water in reducing sickness and death-rates, particularly in cases of typhoid and diarrhoeal diseases, convinced the commission that all waters to be secured hereafter should be either naturally filtered, such as spring or ground waters, or artificially filtered according to the most efficient process.

Several methods of filtration were carefully examined with reference to the local conditions existing at New York, and the commission recommended for the large additional supply the

slow system of sand filtration which is practiced quite generally in Europe and also to some extent already in this country. A careful search was made for the best locations for such filter plants, and designs were made for such filters at Stormville, on the Fishkill watershed, for filtering the additional supply, and examinations were also made for sites not far from Tarrytown to filter the present Croton water.

LONG ISLAND SUPPLY.

A number of examinations were also made regarding the ground-water supplies of Long Island, and this water was found to be very satisfactory, with proper and usual precautions.

The commission recommended that the supplies for Brooklyn and Queens should be increased by a further development of the ground-water supply. Careful and extensive surveys were made over Long Island for this purpose.

The sources of all ground waters, as well as of surface waters, is the rainfall. In order to ascertain the quantity available it is necessary first to determine the quantity of rainfall and its distribution. After the water has fallen to the ground, one part flows off immediately upon the surface into natural depressions of the land, and thence into streams and rivers. Another part is retained for some time by the vegetation; another part is evaporated from plants, water and land surfaces, and still another part percolates into the soil if this is permeable. Of the latter, some is absorbed by the roots, some is evaporated on the surface, some is held in the ground by capillarity, and some descends into the ground until it reaches a plane of saturation. Below this plane is accumulated within the interstices of rocks and soils a large quantity of ground water which percolates through the pores to the lowest levels, where it can escape as spring water into streams, lakes or the ocean. Each of these parts was considered so far as practicable with reference to the conditions on Long Island.

A large number of existing wells were examined, and many new wells were driven in order to ascertain the level of the ground water, its depth, its oscillations, and its flow. Studies were made on evaporation and percolation. The levels of the water surfaces

were observed at frequent intervals in over 1 000 existing wells, and in over 300 new wells which were driven by the department. Over 2 000 sets of samples of soil, found in these wells, were examined and classified. Altogether over 37 000 ground-water observations were taken upon an area which extended over 1 000 square miles.

The commission concluded that an ample supply of about 150 000 000 gallons of ground water could be obtained daily from Long Island, enough to justify a material extension of the present system, and that this quantity should be brought to the city through conduits properly located and provided with pumping stations along their course, so as to allow the ground water to flow into them by gravity through appropriate wells placed at one side of them as frequently as the water yield of the soil in the particular locality would permit, and that their depth should be sufficient to penetrate the saturated gravels of Long Island at least 30 feet below the surface. After exhausting the available island supplies a further increase should be obtained from Manhattan.

The borough of Richmond should at first be supplied with water from New Jersey by a private company, with which a favorable contract was being considered, and later it should receive its water from or by way of Long Island.

The commission further recommended that Manhattan and the Bronx should be, as heretofore, furnished with Croton water, but after it had first been filtered. The additional supply for these two boroughs should be brought through the new, high level aqueduct, which would extend to the new watersheds beyond the Croton. The main and best supplies which this aqueduct could bring to the city are the Esopus and Rondout creeks in the Catskill and Shawungunk mountains.

To obtain the additional supply at once from the Hudson River above Poughkeepsie was found to be somewhat less expensive, including the expense of filtering and pumping to the present reservoir, than to secure any water from the Esopus and Rondout creeks. But the commission believed that the latter sources, from the excellent character of the water and the delivery by gravity at a high elevation, had advantages which made them

preferable at the present time. The longer the time before they could be secured and developed, the more difficult it would become to procure the necessary reservoir sites and water rights. It was therefore deemed best to secure them at first, as the Hudson water would always remain available for a later increase. There are no water rights which attach to it and no expensive storage reservoirs would be necessary. The economy and excellence of the filtered Hudson supply will, moreover, hold in check all excessive demands against the city by private parties for water along the high level streams. It will become the most available source after the growth of the city has reached the limit of the neighboring gravity supplies, and can be relied upon to furnish perhaps 1 200 000 000 gallons per day during the driest years.

To obtain water from so great a distance as the Adirondack Mountains or Lake Erie would be very expensive, on account of the long aqueducts, and this expense is wholly unnecessary and unwarranted, both as regards quality and quantity of the water that would be secured. Modern filtration works, even when applied to a moderately polluted river water, can produce a quality equal to the average ground or spring water, and the quantity available above Poughkeepsie would be greater than that available in the Adirondacks.

The city of Greater New York can be congratulated upon the fact that it has at its command from several sources so abundant a supply of good water which can be brought to it at a reasonable cost.

A WOOD-STAVE CONDUIT FOR THE WATER SUPPLY OF ATLANTIC CITY.

BY KENNETH ALLEN, ENGINEER AND SUPERINTENDENT OF WATER WORKS, ATLANTIC CITY, N. J.

[Read September 15, 1904.]

Among other types of construction that their conservative brother of the East might hesitate to adopt without previous experience, western engineers have demonstrated the adaptability of wood-stave construction for water pipes carrying all but very high pressures. Sufficient experience has been had to establish their durability, ease of construction, and comparative cheapness, so that more or less work of this kind is now being undertaken in the East, notably about 106 000 lineal feet of 30-inch pipe for the water supply of Lynchburg, Va.

Since 1892 the main water supply for Atlantic City has been brought from the storage reservoir to a small reservoir or basin near the Absecon Pumping Station — a distance of about two miles — by an open ditch or canal. When in good condition this canal would deliver about eight million gallons per day, but, owing to erosion and deposits and the rapid growth of aquatic vegetation, its capacity at times in summer was probably not over five or six million gallons per day. Streams were crossed by wooden flumes and their banks were protected by wooden abutments and wings. These structures were, of course, in continual process of decay, and their failure was liable to cause interruption to the water supply of the city. This, in fact, actually happened during the height of the season, in August of 1903, when the city was crowded with pleasure seekers, and resulted in draining the reservoir and cutting down the pressure in the city to twenty pounds per square inch. Fortunately, several new artesian wells were available or the condition would have been yet more serious.

Again, there was constant danger from the burrowing of muskrats, and no little vigilance was required to prevent destruction of the banks from their borings.

Finally, in spite of precautions to maintain the banks, there was always the possibility of a long-continued northeast storm combined with flood tides backing up the water in the adjacent marshes until the salt water would flow over the banks of the canal. This also occurred in the spring and fall of 1903, but by confining the salt water in the canal and drawing it off at low tide it was fortunately possible to prevent its entrance to the city mains.

It will be admitted that this was a somewhat hazardous condition to be maintained. The department was, however, fortunate enough to secure bonds for replacing the canal with a closed conduit, and after comparative estimates it was decided to construct this of wood staves. The following are some of the principal data employed in the design:

DATA

Normal elevation of water surface in reservoir above mean tide,	+5.20
Ordinary elevation of water surface in basin, from	+2.50 to +3.50
Diameter of conduit	42 in.
Total length of tangents	8 610.2 ft.
Length of conduit in one 9° curve	238.3 ft.
Length of conduit in nine 21° curves	958.9 ft.
Total length of conduit	9 807.4 ft.
Gradient	0.016%
Minimum capacity, estimated	8 millions gals. per day
Maximum capacity, estimated	12 millions gals. per day

It was decided to locate the conduit as far as possible in the bed of the old canal, partly to facilitate the work, partly because this was in the center of the right-of-way, and also in order to permit the water supply to be utilized in case of accident to the artesian well supply or of any unusual demand on account of fire or otherwise. Such a contingency did, in fact, arise more than once during the construction of the work. For the same reason it was concluded to construct the pipe in the trench instead of lowering it from a higher level.

Fig. 1 is a profile on the line of the conduit.

It was assumed, that material excavated would all be used in backfilling, the volume of this being calculated from cross-sections taken not over one hundred feet apart; and the specifications

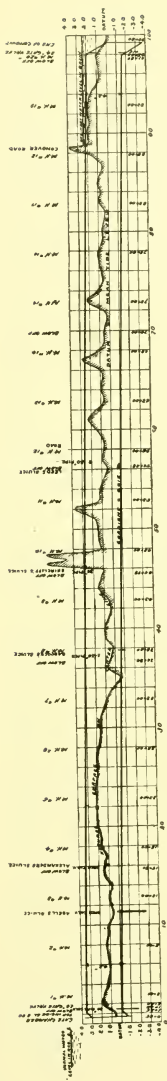


FIG. 1. PROFILE OF WOOD-STAVE CONDUIT.

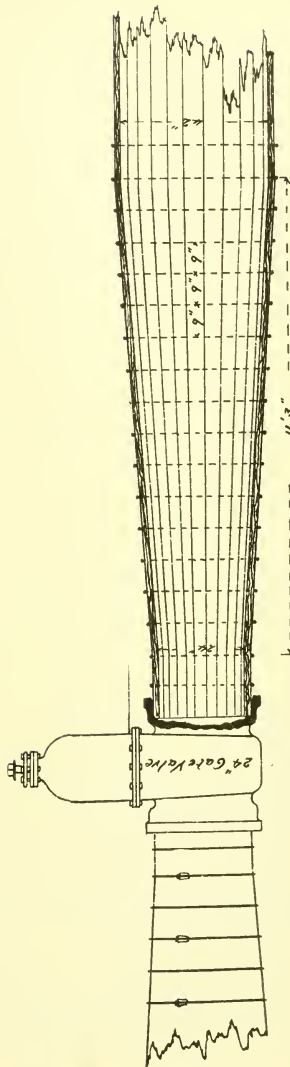


FIG. 2. VALVE AND REDUCER.

called for a lump sum bid for the earthwork required for the conduit based on the volume of backfill (estimated at 7 850 cubic yards), a price per cubic yard for excavation for foundations of gate chamber and culverts, and thirty cents per cubic yard for any extra excavation that might be required.

The method of construction of the conduit is shown in Fig. 3.

The spacing of bands twelve inches apart was determined by the formula $d = \frac{S}{P R + e t}$ in which

S = safe working strength of $\frac{1}{2}$ -inch band in pounds = 3 000

P = maximum static pressure in conduit in pounds per sq. in. . . = 4

d = spacing in inches.

R = inside radius of pipe in inches = 21

e = swelling force of wood per square inch in pounds = 100

t = thickness of staves in inches = 1 625

On other than straight cylindrical pipe the spacing was reduced to nine inches.

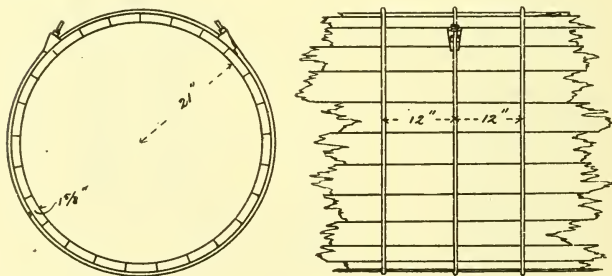


FIG. 3. SECTION OF CONDUIT, SHOWING METHOD OF CONSTRUCTION.

The following extracts from the specifications, together with the details reproduced in Figs. 2 and 6, will indicate the general character of the work:

“*Staves.* The quality of the lumber used for staves is considered of prime importance and will be subject to rigid inspection. Staves of material or shape not conforming in every respect with the intent of these specifications will be rejected and shall be

at once replaced by the contractor with staves conforming therewith.

"The staves shall be either of California redwood, Long Leaf yellow pine, southern cypress or of Oregon, Washington, or Douglass fir, and bidders are asked to specify on which of these their proposal is based.' The staves shall be made from perfectly clear, first quality lumber, as well seasoned as the market affords, perfectly sound and free from sap, spongy grain, knots, shakes, dry rot, pitch seams, cracks or other defects that may impair its strength or durability. The stave lumber shall be placed on sticks immediately after being sawed, so that the air may freely circulate between and around it, and shall remain on said sticks until manufactured into staves. Before the manufacture of staves is commenced, templates must be submitted to the engineer for his approval."

The lumber used was Washington fir, from the Wallace Lumber Company of Startup, Wash., and was of exceptionally fine quality so that there was practically no loss from culling. In a large sample lot of staves the extreme lengths noted were 9 and 33 feet, $6\frac{1}{4}$ per cent. being under 12 feet and 25 per cent. under 16 feet. The minimum length allowed was 10 feet. They were cut from 2-inch by 6-inch lumber and measured $1\frac{9}{16}$ inch in thickness and $5\frac{3}{8}$ inches on the inner surface.

The ends were square and contained a kerf to receive a $1\frac{3}{8}$ -inch by $5\frac{3}{4}$ -inch tongue of No. 12 gage iron.

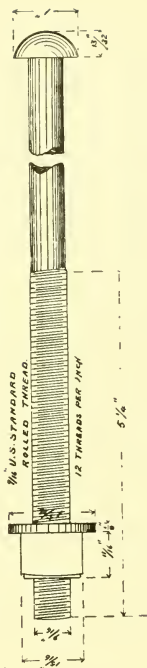
"*Bands.* The bands shall be of homogeneous 'mild' steel having a tensile strength of from 55 000 to 65 000 pounds per square inch of section; an elastic limit of at least sixty (60) per cent. of the tensile strength; an elongation in eight (8) inches of not less than twenty-five (25) per cent.; a reduction of area at point of rupture of at least forty-five (45) per cent., and shall be capable when cold of being bent back flat upon itself without showing signs of fracture.

"The threads at end of bands may be pressed or the rods upset and threads cut, but the ends shall be stronger than the body of the band, and this shall be proven from records of tests to be made by a reputable firm of inspectors, certified copies of which shall be furnished the engineer.

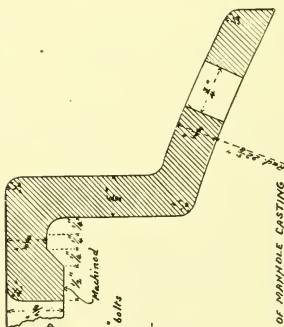
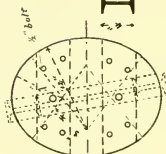
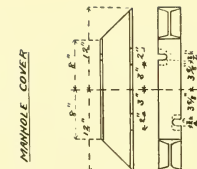
"Especial care shall be taken to avoid injury to threads in shipping and handling the bands.

"All bands shall be provided with the necessary nuts and washers; the nuts shall be of such length, from face to face, and

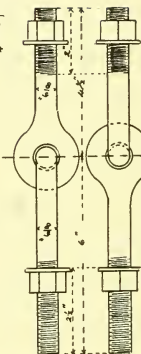
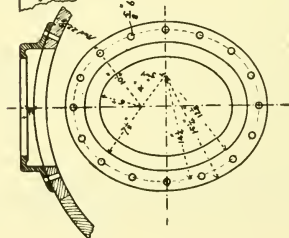
1/2-INCH STEEL BAND



MANHOLE COVER



DETAILS OF MANHOLE CASTING



EYE BOLTS FOR COVER

FIG. 4. DETAILS OF BANDS AND MANHOLES.

shall fit so close to threads as to secure a resistance to stripping at least equal to the tensile strength of the body of the band."

The bands were manufactured by the Cambria Steel Company with pressed threads and, with the malleable iron saddles (from the Fort Pitt Malleable and Gray Iron Works of Pittsburgh), were inspected by W. R. Conard, member New England Water Works Association.

Details of the bands are shown in Fig. 4, and the saddles in Fig. 5.

"Preparation of Bands. The bands, nuts, washers, and saddles shall be thoroughly cleaned of all scale, rust, oil, dirt, etc., and the bands bent around a bending table to fit the exterior circumference of the pipe.

"After being cleaned they shall be coated in the field by being dipped in hot mineral rubber or other material equally good, to be approved by the engineer, after having been heated to 400° F. This coating must adhere firmly to the metal and must not flow at a temperature of 150° F., nor be brittle at 32° F. It must cover the metal perfectly to a thickness of at least one fiftieth (1-50) of an inch. The bands shall then be set aside to allow the coating to properly harden before subsequent handling."

The bands were first bent to the proper radius by winding them about a short cylinder or bending table 38 inches in diameter, or about seven inches less than the diameter of the band required. After bending they were tied by wire in bunches of five for coating.

The question of coating of the bands was deemed all-important, as being the chief element determining the life of the conduit. It was believed that considerable abrasion would be inevitable in transportation and that if coated after delivery the danger from rust would be very small. It was found impracticable in the cold winter weather to maintain a given temperature in the kettle. The condition of the coating depended quite as much on the temperature of the band when immersed. After a few trials the time for heating the bands to secure the best result was determined and adhered to until a change in the temperature of bands, coating, or outer air required a change: it varied from 2½ to 5 minutes and averaged about 3 minutes. After dipping, the bands were hung up, when the coating stiffened, and they were

then piled up for delivery on the work. From seven hundred to eight hundred bands bent and coated was an ordinary day's work

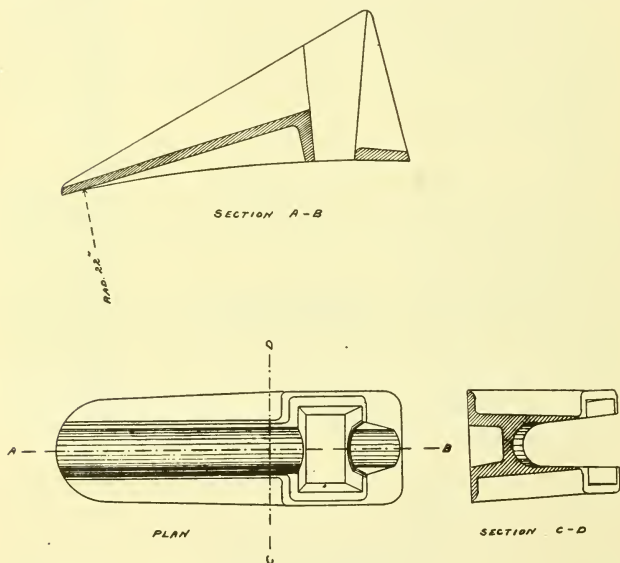


FIG. 5. SADDLE.

for a foreman and seven men. For this about twenty gallons of the mineral rubber were required.

“Construction of Conduit. In building the conduit the staves shall be made to break joints and the ends of two adjoining staves shall in no case be nearer than eighteen (18) inches. Proper wooden mallets shall be used in rounding out the pipe, and if required wooden driving bars for making the end joints tight. Bands shall be placed at right angles to the center line of the pipe.

“ Since the life of this pipe depends upon the integrity of the coating on the bands, saddles, etc., the contractor and his men shall use every care and precaution to save and keep the coating perfect. The coated bands, saddles, etc., shall be handled so as

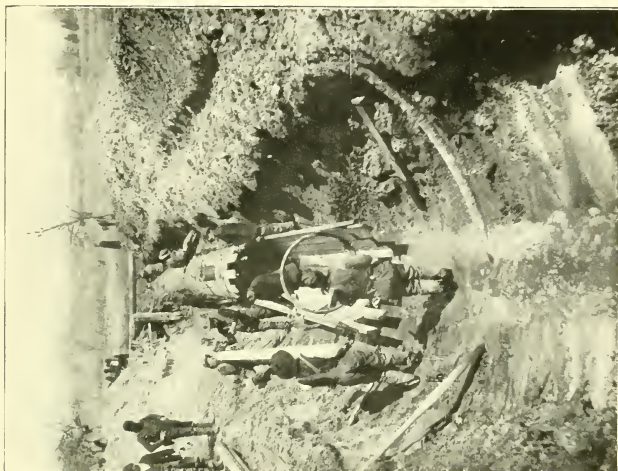


FIG. 1.



FIG. 2.

to prevent, as far as possible, any damage to the protective coating, and should the inspector find any on which the coating is imperfect or has been damaged, they shall be rejected and at once removed from the work, and not again brought on the work, unless they have been recoated.

"The coated band shall be cinched and (but only if necessary) hammered very carefully with wooden mallets. The band, nut, washer, and saddle shall then receive a heavy coat of Mineral Rubber Field Paint or hot mineral rubber. This work shall be done by careful and intelligent workmen, and will be rigidly inspected.

"On each side of the gate valves the conduit shall be conical in shape for a length of eleven feet, the required taper being secured by the proper uniform reduction in the width of the staves as shown on the plans, or by the insertion of suitable wedge-shaped pieces.

"After being thoroughly cleaned of all earth, sand, dirt and rust by wire brushes, the castings shall be coated with mineral rubber as already prescribed for the saddles. No acid shall be used in cleaning castings. In case the coating cannot be applied immediately after cleaning, the surface must be preserved by a thorough application of linseed oil.

"Great care must be taken by the contractor not to overstrain the bands during construction, and when filling the pipe with water for the purpose of testing the same. No wrench over sixteen inches in length shall be used in cinching."

Trenching was begun on February 4, and the conduit proper was completed on April 16, 1904. (See Plate I, Fig. 1.)

The material excavated was largely sand; but clay, quicksand, gravel, mud and roots were also encountered in varying quantities. A section of the canal was dammed off and pumped out by one or two portable three-inch gasoline pumps while the trench was excavated and the conduit laid.

The pipe gang consisted of from 9 to 12 men. Usually there were, 1 foreman, 2 men handling material, 2 men driving staves, 2 men tightening bands, 1 man rounding out by hammering inside, 2 men back-cinching, 1 boy painting bands, 2 men tamping. At times two pipe-laying gangs were employed.

There were also, 2 day men on gasoline pumps, 2 night men on gasoline pumps, 2 men on diaphragm pumps, 35 men backfilling.

The sections were finally united by cutting staves to the required length and springing them into place.

Two 24-inch Rensselaer gate valves were placed in the line, one at each end. (Plate I, Fig. 2.) For eleven feet each side of the valves the conduit was made conical in shape by planing the staves to the proper taper, as shown in Fig. 2.

Curves were turned by prying over the end of each section as laid to the proper position before back-cinching, holding it in position by struts and backfilling until finally secured by back-cinching. (Plate II, Fig. 1.)

There were several double 30-inch vitrified pipe culverts and two open culverts on the line. The latter were 22 feet between faces of abutments, but a pier supported the conduit in the center of the span. (See Plate II, Fig. 2.) After the concrete masonry had set, wood collars were placed 12 inches from each abutment and 8 inches from each face of the pier on which an outer sheathing of staves was constructed similar to the enclosed conduit. The annular space next the masonry between the conduit and the sheathing was then filled with grout forming a solid ring to prevent leakage at the ends of sheathing staves, and a $\frac{3}{4}$ -inch hole was bored in the conduit. The sheathing protects the conduit from floating substances and the water jacket insures its saturation, by which decay is delayed.

The two ends of the conduit are depressed, as shown in the profile, Fig. 1, and there are 11 air vents of 2-inch galvanized pipe with perforated caps, set vertically in the crown of the conduit, the former to prevent the entrance of air and the latter to insure its escape while the conduit is being filled. There are also 20 man-holes (Fig. 4), and six 6-inch blow-offs (Fig. 6), for use in inspections and repairs.

The conduit was first tested for leakage by closing the valves at each end of the line, laying a 2-inch pipe connecting the force main with one of the air relief pipes, and inserting a 1-inch meter. A piece of 2-inch pipe was screwed on to the air relief, of such length that when the pressure reached ten pounds it would overflow without straining the structure. Several leaks were developed by raising the pressure to seven pounds, and the amount passing proved too great for the meter to register. The 2-inch line was then converted to a steam line and a feed pump used both for charging the conduit and measuring the leakage



FIG. 1.



FIG. 2.

(by displacement). A few more leaks, which were insignificant in size, were discovered and calked, reducing the leakage to about 78 gallons per minute, or just one gallon per day per square foot of exterior surface of the conduit.

The contract price for the pipe laid, without earthwork, man-holes, blow-offs, etc., was \$2.25 per lineal foot, and the total cost of the work, including inspection, was \$30 412.90.

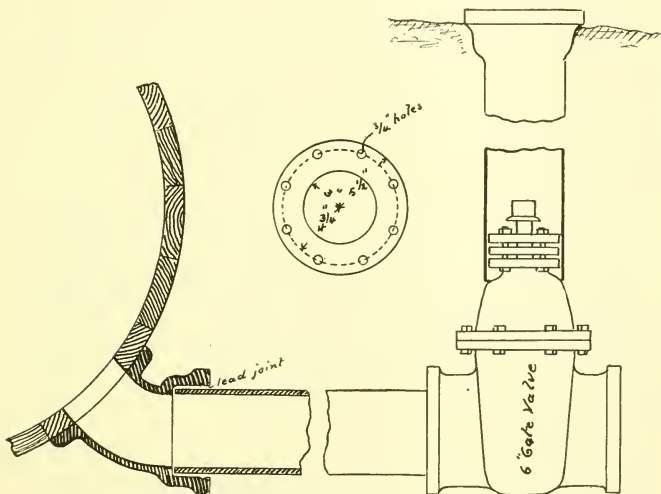


FIG. 6. BLOW-OFF.

The work was done by the C. P. Allen General Contracting Company of Denver, who agreed to maintain it for two years and deliver the same in good condition at the end of that period. Mr. Henry Goldmark, member American Society of Civil Engineers, of Montreal, acted as consulting engineer in the preparation of plans, and Mr. C. J. Myers, Junior American Society of Civil Engineers, was the assistant engineer of the department in direct charge of the work.

So long as suitable lumber can be had at a reasonable price it is believed that wood-stave pipe will be found more and more in favor with engineers under certain conditions, *viz.*:

Where, from the nature or location of the ground, transportation is difficult.

Where, on account of the surrounding soil, corrosion would be particularly active.

In the many cases where wood-stave pipe can be laid at less cost than that of iron, steel or masonry.

Where the greater weight of other material on the underlying soil would be objectionable, as in crossing marshes and swamps.

Aside from the design and proper proportioning of parts to resist the water pressure, the successful application of wood-stave construction depends mainly on two things — the lumber and the coating of the bands.

Redwood has found favor in the past, but it is understood that the supply is becoming reduced so that it is gradually being forced from competition. Washington or Oregon fir can be had for many years to come in all merchantable sizes and of the finest quality. In spite of the freight charges, which were here something over \$300 per car load, this seems at present the most available lumber for the purpose, as it can be had on short notice and as there is little loss from culling. Southern cypress would be suitable, but the supply is limited, and the same is probably true of cedar.

Aside from California redwood, southern pine is perhaps the one competitor of western fir in our markets. This can be secured in large quantities of sufficiently good quality, by moderate culling, for satisfactory results, and would probably be the most economical in the southern states.

Although the specifications for lumber are in other respects quite rigid, it will be noted that no stress was laid on seasoning, and it is believed that the importance of this is generally exaggerated. Mr. Allen states that he has used perfectly green lumber in one instance; and, while this is not a practice to be commended in general, the work proved satisfactory. On this point Mr. Goldmark wrote: "I do not think it necessary or feasible to require a very long seasoning, and I think greater softness of the

unseasoned wood would be an advantage in obtaining tight joints."

The objection to the use of very short staves is in the increased number of joints. This, it is claimed by Mr. C. P. Allen, who is believed to be the pioneer in this type of construction, does not materially affect the leakage or durability of the pipe, but does increase the cost of construction, as it takes nearly the same labor to put together a 12-foot section as one 24 feet in length. The minimum length of stave allowed may, therefore, with advantage be not over 9 or 10 feet, as this permits the utilization of a large percentage of lumber that would have to be rejected under a 12- or 14-foot limit.

With regard to the coating, a short section of pipe was buried in salt marsh mud after coating the bands, saddles, and nuts with mineral rubber. On being examined after fourteen months, the coating was found fresh and elastic and the metal untarnished. This led to our adoption of a similar coating for the bands. But our experience with Durable Metal Coating as a field paint caused its adoption for giving the iron work a final coating before backfilling. Where rapidity in drying before backfilling was essential, P & B Paint was used to some extent, and the results appeared satisfactory; but in general the Durable Metal Coating dried sufficiently before the backfilling was done.

SOME ADDITIONAL NOTES ON THE WOOD-STAVE CONDUIT AT ATLANTIC CITY, N. J.

BY C. J. MYERS, ASSISTANT ENGINEER, WATER DEPARTMENT, ATLANTIC CITY, N. J.

It may be of interest to some to know more of the conditions that governed the design of this conduit and the reasons why certain details were chosen.

When the canal which this conduit replaces was in use the average difference in level of the water at the two ends was about 1.5 feet. It was decided that the new conduit ought to carry with the same loss of head about 8 000 000 gallons per day, this being the estimated minimum amount that the stream would supply.

Taking c in Chezy's formula to be 110, this gave a 42-inch conduit as the nearest commercial size.

This value of c (110) has not, as yet, been checked by experiments on the pipe itself, but as the conditions are unusually favorable for experiments they will probably soon be made.

In selecting the grade line of the pipe itself it was necessary to make sure that the pipe would be under sufficient head to keep it saturated, and it was also advisable to keep it as high as possible to avoid expensive excavation. Since the pipe was laid in the bed of the old canal, a slight increase in the cutting made a marked difference in the amount of excavation. For these reasons it was decided to make the elevation of the top of the pipe inside as follows:

<i>Sta.</i>	<i>Elev.</i>
0+00	+3.00
0+60	+3.50
96+70	+1.95
98+00	+0.00

These elevations are above mean tide level as determined by the United States Geological Survey.

The grade line determined by these elevations gives, when drawing at an eight-million gallon rate, a head of about two feet of water on all parts of the pipe line. This, it is thought, will be sufficient to keep the staves well saturated and therefore free from decay. This grade line also ran nearly parallel to the profile of the bottom of the canal, thus making the excavation a minimum.

In the last 130 feet of the conduit, where it enters the reservoir, the grade line drops 2 feet. This was done in order that the pipe might be used, at some future time, as a siphon.

The flow through the conduit is regulated automatically by the elevation of the water in the lower reservoir. As the quantity of water pumped increases, the level of the water in the lower basin falls until the difference in head between the two ends of the pipe is just sufficient to cause the quantity being used to flow through.

By putting a check valve, which will permit the escape of air from the pipe but will not allow it to enter, on each air pipe on the lower 5 000 feet of the pipe line, it will be possible to use the pipe

as a siphon. The lower reservoir can then be drawn down to elevation 0 and the conduit will still flow full; whereas at present, in order to keep the conduit full of water, the elevation of water in the lower basin must not be lower than +2.0.

The amount of air accumulating in the pipe while it is being used as a siphon will be small, as the lower 5 000 feet of the line, on which alone this siphon action will occur, is nearly all below the ground water level. Of course the rate of flow obtained when using this siphon action will be much above the average and will last only a few hours at most. As soon as the water rises in the lower basin above elevation +2.0, all the air that may have leaked in or accumulated in the pipe while it was used as a siphon will be forced out, and the pipe will thus always automatically keep itself clear of air and ready to be used as a siphon.

This additional two feet of head should give an increase of over 25 per cent. in capacity, the pipe flowing full in each case.

All changes in direction in the old canal were made with very short bends, and as we wished to stay in the old channel as much as possible, in order to avoid excavation, we wished to use the shortest radius curves that it would be practical to build. After examining all the available literature on the subject, a 24-degree curve was decided on. These curves were built without particular trouble, though they seemed to be as sharp as it would be advisable to try to build.

In laying the pipe it was, of course, impossible and unnecessary to keep exactly to the calculated grade of .016 per cent. Care was taken, however, to make sure that the pipe was not above grade, and that it had no sharp dips or summits that might trap air.

After half the air pipes had been placed and the conduit used for some time, it was decided to place air pipes halfway between those already set. This was done, and in boring the holes to set them no air was found, which seemed to show that the velocity of the water was sufficient to carry the air along until it reached an air pipe.

Although the conduit is 42 inches in diameter, 24-inch gate valves were used because they were cheaper and because one man can manipulate them easily. The loss of head in the two conical sections and gate valve, when flowing at the rate of 5 500 000

gallons per day, is about .11 foot. Only one measurement has been taken, so that the loss at other velocities is not known.

The staves came in box cars and were first sorted in piles according to their length in feet, ignoring the inches, and then distributed along the line in piles of twenty-five each.

In making up a section, the foreman usually tried to keep all the joints within a space of from 4 to 6 feet, to facilitate driving the staves. Where these joints come is, of course, the weakest point in the pipe, and in soft ground the spacing of the bands was decreased at these joints to 9 inches on account of the danger of the pipe settling and pulling at the joints.

Although a great deal of backfilling was done with frozen earth, but little distortion of the pipe occurred. Its dimensions average about 41.5 inches in vertical diameter and 42.5 in horizontal.

Leaks that occurred were all small, and were calked from the outside with wedges of wood.

A comparison of the cost per lineal foot of pipe for the first 26 per cent. of the length with the cost of the remaining 74 per cent. shows a marked difference. The following table gives the cost of labor alone in hours per lineal foot of pipe:

<i>Period</i>	<i>Cost of backfilling and excavation per lin. ft.</i>		<i>Cost of making pipe</i>	
	FOREMAN	LABOR	FOREMAN	LABOR
Feb. 4 to Mar. 5	.28 hr.	4.92 hrs.	.13 hr.	1.05 hrs.
Mar. 5 to Apr. 16	.18 hr.	4.91 hrs.	.07 hr.	.73 hr.

The difference was probably nearly all due to the very severe weather experienced in the first period, though some of it was undoubtedly due to the fact that the gangs, more especially the pipe-building gangs, were new at the work. During the first period some soft mud was struck that was hard to work in, but that was balanced by the fact that there was less excavation per lineal foot, and not nearly so much water to handle, as in the second period. Common labor cost about 15 cents an hour for backfilling and excavation and 20 cents an hour for building pipe; foremen, from 25 cents to \$1.00 an hour, probably averaging about 40 cents.

DISCUSSION.

MR. FRANK L. FULLER.* I should like to ask Mr. Allen how the cost of coating the bands compared with the cost of galvanizing, and how satisfactory it was.

MR. ALLEN. I think any ordinary galvanizing would be likely to be imperfect. The cost of the coating was small, but I cannot say just what it was or how it would compare with the cost of galvanizing. Where imperfections existed, they were easily covered up by painting over before backfilling.

MR. FULLER. I should like also to ask with regard to laying the pipe to grade, whether any plank or timber were used under the pipe.

MR. ALLEN. They put a block or piece of plank under the end of a section as it was laid, but that was afterwards taken out, and the sand was so soft that it flowed in and filled up the space. The matter was considered before doing the work, and we decided it would not be necessary to leave the plank in.

MR. FULLER. There wasn't any settlement of the pipe?

MR. ALLEN. Not that I know of. If there were, it wouldn't do any harm, for the conduit was stiff enough to keep its general form, and would not settle very much in any one point.

A MEMBER. I should like to ask if the saddle was one you designed yourself, or if it is patented.

MR. ALLEN. I don't think there is any patent on it. We designed a saddle, but the contractor had one of his own which conformed almost precisely to what we had designed ourselves, so we let him use his own design.

MR. W. C. HAWLEY.† This paper has been of particular interest to me, as I am so familiar with the Atlantic City plant. The matter of a wooden stave conduit was first considered there in 1899 or 1900, and after I had made a recommendation to the commissioners that such a pipe be used for the force main, we called in Mr. Kuichling, a member of this Association, as consulting engineer, and on his recommendation I made a trip to the Pacific coast with some of the commissioners and members of the Council, and investigated some stave pipes which were then being

* Civil Engineer, Boston, Mass.

† General Superintendent, Pennsylvania Water Co., Wilksburg, Pa.

built, and some which had been built previously; and we were so favorably impressed with the pipe that we recommended its use in Atlantic City, and it would have been used then had not the opposition of the steel pipe men been so effective as to prevent it. But I have had the satisfaction since of being told by one of the men who was most active in that fight that had he realized what the conditions were in Atlantic City across the soft mud he would not have opposed the stave pipe, and that he believed that a mistake was made in putting in steel pipe.

What we saw in the West made me wonder why such pipe is not used in the East, especially in the larger sizes; not, of course, for such an aqueduct as Mr. Hering has described for the supply of New York City, but 30 inches in diameter or even larger. The cost would be less for pressures up to say 60 or 75 pounds, and the construction is easier. You have in it a pipe that is without the drawback of lead joints, like a cast-iron pipe; a pipe of considerably greater capacity than a riveted steel pipe, or than a cast-iron pipe after it has become tuberculated; and the ease with which the line can be constructed, the ease with which the material can be taken to difficult locations, is also very strongly in its favor. The "stunts" that can be done in laying the pipe around curves and up and down hills is almost beyond belief until you see them done. I saw one place in Butte, Mont., where in a distance of 500 feet they went down into a ravine 100 feet deep, crossed the ravine, which was 50 feet wide at the bottom, and came up to grade on the opposite side. At Seattle we saw a 44-inch line being laid through virgin forest, where they had to clear out some of those Washington fir trees. The butts of many of those trees are 50 inches in diameter, and that is the kind of wood of which the staves used at Atlantic City were made.

At Butte they were constructing a long line for a new supply for the city, and in order to avoid excessive pressure on the pipe — I believe they limited it to 75 pounds — they would lay a section of pipe until the pressure had reached the limit, when they would construct a small basin with a float valve, on the same principle as a water-closet tank, and then they would lay another section and construct another basin, and so on down for a distance of some twenty miles all told; and in that way they were able to

use this wood stave pipe in all except one or two short sections where they had to cross ravines or cañons or something of that kind. I think if the merits of this pipe were more generally understood here in the East it would be used to a considerable extent, and it is something worth looking into by anybody who has a pipe line to lay under a limited pressure.

MR. ALLEN. I might say that the steel pipe line to which Mr. Hawley has referred seems to be holding its own pretty well, but there is no way of telling what corrosion may be going on in the bottom; and of course any failure of the pipe would be likely to be serious, while with a wood stave pipe any trouble could probably be remedied without difficulty. You can replace a band or replace a stave or rebuild a whole section without very much trouble, but if several leaks should occur in the bottom of this steel pipe, which is laid across a salt marsh, — and the marsh is particularly hard on steel if it comes in contact with it, being saturated with salt and vegetable acids, — the situation would be quite serious. It seems to me a great mistake was made, as Mr. Hawley says, in not using wooden stave construction in that place.

MR. FULLER. I didn't exactly understand Mr. Allen's description of the way the staves were joined at the ends. Is there something in the nature of a tongue and groove?

MR. ALLEN. There is a little tongue, consisting of a small piece of sheet iron, that is inserted in a slit in the end of each stave, between two adjoining staves, so that when they come up to each other the iron prevents any percolation of the water between.

MR. FULLER. Are the staves of the same width?

MR. ALLEN. Yes, of the same width.

MR. FULLER. Didn't that necessitate the wasting of more or less lumber?

MR. ALLEN. No; I think it saved it, because each section was exactly like the adjacent sections. All the sections were just the same size in circumference. It took just twenty-five staves to go around. There was a bead on the edge of each stave, with the idea that in cinching up it would make a closer contact with the next stave, although I think there would have been no diffi-

culty in making it tight without that bead. Still, it was as easy to cut the stave out with the bead.

MR. FULLER. Would it be possible to make a pipe of this kind sufficiently tight to serve as a suction pipe, do you think?

MR. ALLEN. I should doubt it. If it was under water it might be done, but I don't know. I should not want to risk it, however, without knowing more about it.

MR. T.W. MANN. I haven't had any experience with these pipes for delivering water for water works purposes, but I have had more or less experience with conduit pipes from the wheel pit. We have used a 9- or 10-foot intake made of 3-inch plank grooved and tongued, of southern pine, hooped with iron about every two feet. They have been used for years, but lately they have been taken out, and they are being replaced with steel, because in our canal the pipe cannot be kept under water all the time, and when the water goes down the pipe will be exposed, and I don't think it was tight enough so that the air would not get inside and rot the wood. The planks were grooved on the side and had no end groove.

A MEMBER. I think perhaps Mr. Hawley might be able to give us some information obtained on his Western trip as to the length of life of these pipes.

MR. HAWLEY. I think really there is more definite information on that point to be obtained in the East than in the West. I have seen pipes taken up in the city of Philadelphia which had been in for about a hundred years, and the wood was perfectly good, as sound as when it was put in. The question as to the preservation of the staves depends entirely on whether they are saturated and kept saturated. At Cheyenne, Wyo., they laid a line which was not always kept full, it was kept about two thirds or three quarters full, and the pipe rotted in a few years, and was a failure. We saw at Butte a line which had been in for nine years at that time, and we saw one place where a washout on the mountain side had uncovered it, and it appeared to be perfectly dry, but on taking a pen-knife and sticking the point into the wood, the water squeezed out on both sides of the blade, showing that the wood was saturated clear through to the outer surface. In looking up the matter with special reference to the conditions at Atlantic City, we found a line of telephone poles across the meadow had

rotted off above the sod of the meadow, but within four or five inches of the surface they were perfectly sound and good. And while we were making the investigation a gentleman who lived on the mainland told us of some piles he had seen his father drive in 1860, and he procured a piece of one of those piles for us. It was a cedar pile. He cut it off six inches below the surface, and it was perfectly sound and good, and after it had been dried the odor of cedar was distinctly noticeable. It was under the sod in the soft meadow where it had always been kept wet.

The staves must be kept saturated continually; that is the secret of preserving the pipe. In Salem County, New Jersey, they are doing quite a business in digging up trunks of cedar trees which fell nobody knows how many years ago and were buried up in the swamp. They go in with a sounding rod and sound over the mud till they strike one of these trunks, and they get hold of it and pull it out and then make shingles of it.

MR. ALLEN. Rather an interesting thing came to my notice in building a dam about a year ago. We excavated through about two and a half feet of gravel, and then six feet of clay, which was evidently the original formation, apparently never having been disturbed, and under that we found quite a quantity of cedar which was perfectly sound although the strength had gone out of it. The fibers did not appear to have been rotted at all, but they did not adhere to each other. You could tear them apart easily. That wood may have been there for ages, — there is no knowing how long. Mr. Hering tells me that at St. Louis they have some specimens from Switzerland that have been under water for perhaps several thousand years, and they are perfectly sound yet.

THE HOLYOKE WATER SUPPLY.

BY A. M. FRENCH, MEMBER BOARD OF WATER COMMISSIONERS,
HOLYOKE, MASS.

[*Read September 15, 1904.*]

High on the list of institutions of which Holyoke is justly proud is her magnificent system of water works, which furnishes to every part of the city a supply of pure water sufficient for all contingencies. The story of its conception, birth, and continuous growth up to its present maturity is full of interest.

Sixty years ago Holyoke was "a small hamlet or neighborhood of farms nestling in the bends of the Connecticut," and known as "The Fields" or Ireland Parish. It contained fourteen houses, a schoolhouse, a small gristmill, and a cotton mill.

In 1847 several Boston men, having a knowledge of what had been done on the Merrimac River, at Manchester, Lowell and Lawrence, associated themselves together to develop a new city and a new water power on the Connecticut, and in 1848 were incorporated under the name of the Hadley Falls Company. As they were mostly cotton men, their idea was to found a cotton city; and there is still in existence a map of the new city as they planned it, with canals, streets, and public squares all marked out, and spaces allotted for over fifty large cotton mills.

Having purchased eleven hundred acres of land, they commenced the construction of the first dam, which was completed November 19, 1848, and disappeared "by way of Willimansett" the same day. At about the same time they provided for a water supply for the town by the construction of a reservoir on the plot of land bounded by High, Maple, Lyman, and Fountain streets, and including the entire square where Dillon's Block now stands. The pond was entirely artificial. A tank was erected, not excavated, with walls 15 feet high and 40 feet thick, and was divided into two sections, so that one would be available while the other was being repaired or cleaned. It held 3 000 000 gallons of water, which was pumped into it from above

the dam, through a 13-inch pipe, by means of pumps located in the gate house. The water stood at an elevation of 177 feet, or 77 feet above the crest of the dam. Thirteen thousand feet of pipe were laid, and as fast as new streets were opened, they were piped.

Water was first pumped into the reservoir October 19, 1849, and the next month saw the work completed. In 1857 the Hadley company failed, and the water works passed into the hands of the Holyoke Water Power Company.

Although the working of the reservoir was never entirely satisfactory, and complaints became more numerous and emphatic as the town increased in size, no action was taken in the matter until August 2, 1871, when a meeting of citizens was held at the office of Judge Buckland. A committee was appointed consisting of John C. Newton, James G. Smith, Timothy Merrick, W. B. C. Pearsons, and John E. Chase, with instructions to inquire into the practicability of supplying the town with water and the cost of so doing, to give the matter a thorough investigation, and to report at an adjourned meeting. This committee secured the services of an engineer, and commenced their work.

Five plans were suggested:

1. To supply the flats from the canal, and the hill from the reservoir.
2. To pump water by steam from the river above the city.
3. To take water from the Whiting Street Brook.
4. To make use of the mountain ponds lying three miles to the southwest.
5. To make more efficient the existing system.

Five weeks later the committee reported that a pure and ample water supply could be obtained from the ponds at an estimated cost of \$174 000, and unanimously recommended this plan.

The location of these ponds, and of the other sources of supply mentioned in the paper, is shown on the map, Fig. 1.

Meantime events had occurred which caused a general and intense interest in the subject. In the summer of 1871 there was a protracted drought, and just at its height the machinery for pumping water gave out, so that for three weeks it was with the utmost difficulty that enough water could be procured for bare existence.

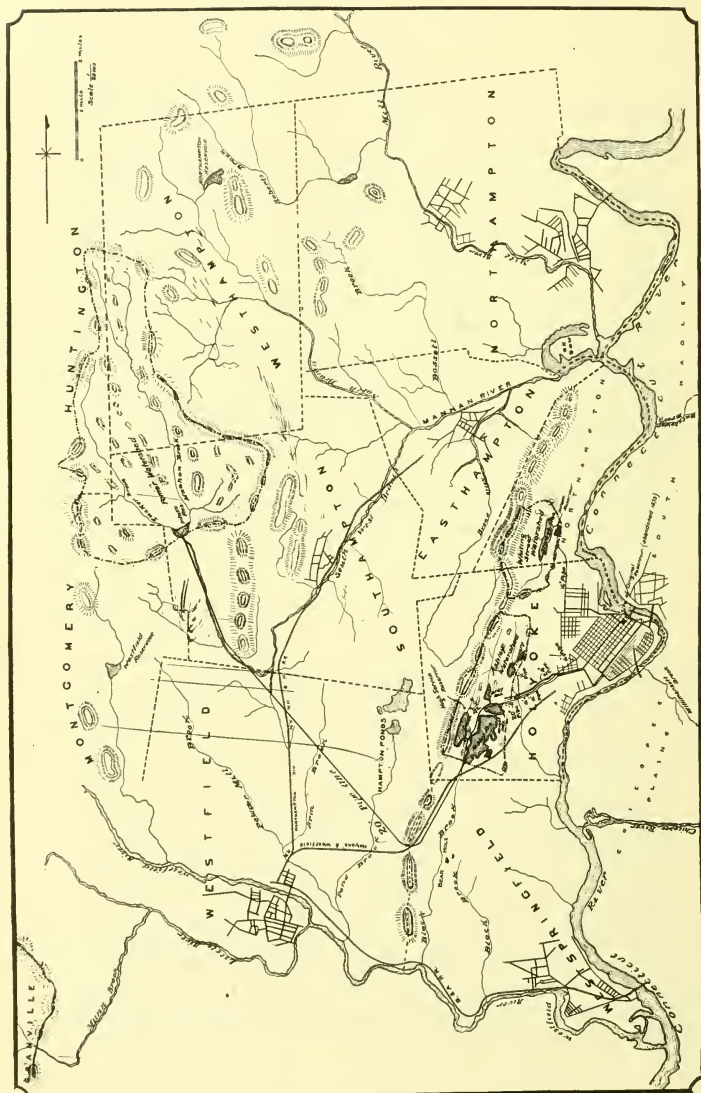


FIG. 1. MAP OF HOLYOKE AND VICINITY, SHOWING SYSTEMS OF WATER SUPPLY.

These words, taken from the *Transcript* of September 9, 1871, strikingly depict the woes of the community: "The local water famine is over for the present. The water brigade, with its pails and buckets, has ceased to wend its dripping way through the streets, and retired from active service. The perambulating water barrels have ended their journeys to and from the river, and their drivers do rest from their labors. The washerwomen have again the wherewithal to ply their trade, and tidy housewives have done their three weeks' washing and regained their wonted cheerfulness. Cleanly people have resumed their habit of daily ablutions and a few bolder spirits have even ventured to take a bath in the precious fluid."

The feelings of the community, in view of these experiences, are well voiced by the *Transcript* in the same issue:

"The town has learned thoroughly that a regular and inexhaustible supply of pure water, with sufficient head for use in every part of every building in town, has come to be a necessity. It is a large undertaking and one which many of our citizens have been inclined to postpone until the town should be larger and richer; but the events of the last three weeks have converted the advocates of delay to the party of action.

"Public water works owned by the town, managed by the town for the benefit of the town, is the need of the hour, and if the expense shall be found to be within reasonable limits, we predict a hearty and unanimous movement to secure this public blessing."

This prediction of the *Transcript* was speedily fulfilled. The town meeting called for the purpose accepted the plans outlined by the Citizens' Committee, and in the following winter the necessary legislation was obtained.

The first water board of Holyoke, consisting of W. B. C. Pearsons, Dennis Higgins, John Delaney, J. P. Buckland, Joel Russell, and John E. Chase, was chosen March 21, 1872. It held its first meeting in Judge Buckland's office in Carter's Block, and organized with Mr. Pearsons as chairman, Judge Buckland, secretary, and Mr. Russell, treasurer. It then proceeded with great energy to the business for which it had been created.

Ashley and Wright's ponds lie a little more than three and a

quarter miles from the City Hall. They have a watershed of $3\frac{1}{4}$ square miles, and a flowage area of $185\frac{1}{4}$ acres at the natural level. It was decided, however, to construct the dam, gatehouse, and embankments so as to admit of raising the water level five feet, this to be done gradually at the rate of about one foot per year, thereby materially increasing the flowage area and about doubling the storage capacity.

At first only the ponds and the land absolutely necessary were purchased, but it has been the policy of the board, steadily adhered to through all these years, to acquire the surrounding lands little by little, until now, in 1904, practically all the watershed of the system is in possession of the city.

After determining the route, careful attention was given by the board to the kind and size of pipe to be used. Being new questions to most of the members, the matter was exhaustively studied and the final decision was to use only cast-iron pipe, on the ground that it would be poor policy to lay anything except the best, and to use two sizes, 20-inch for the first 1 600 feet and 16-inch for the remainder.

Having settled these questions, the board was ready early in May to give out contracts, which were awarded as follows: For supplying pipe, to J. W. Starr & Co., of Camden, N. J.; for laying same, to E. B. Allen & Co., of New Britain, Conn.; for excavating, to John McCoy & Sons, of Holyoke; for building a dam at the outlet of the ponds, gate house, and culverts over the trench between the ponds, to Goldsmith & Norton, of New Britain, Conn.

These contracts called for the commencement of the work by June 1, 1872, and its completion on or before October 15 of that year. All piping was to be delivered by September 1. As a matter of fact, however, the last cargo of pipe did not come to hand until December 15, three and a half months late. Owing to this delay, and to unforeseen obstacles encountered in excavating, it was not until August 6, 1873, two months after the contract time, that water was let into the mains.

In the *Transcript* of July 26 appeared the following: "Work at the ponds is progressing finely, and the great work is nearly done. The water should be in the pipes next week, barring accidents, and the week after, whether or no. There will be a general

rejoicing when it does come, and we believe it will be the greatest blessing that could be given us. Won't there be a lot of happy fellows and others floundering in bath tubs! Even the yard toads will rejoice as they sit under the spray of the fountain."

Meantime a most curious controversy had arisen between the board and the town treasurer, Mr. C. W. Ranlet. In accordance with the provision of the legislative act, the board caused bonds to be issued to the amount of \$250 000, payable in 1900, and bearing interest at the rate of 6 per cent. payable semi-annually. These bonds when printed were sent to Mr. Ranlet, who retained them in his possession, claiming that their control and custody belonged to him, and also the handling of the money accruing therefrom. The board was of the contrary opinion, and at length, after many attempts to reach a satisfactory settlement, appealed to the Supreme Court for a writ of mandamus, compelling the surrender of the bonds. A hearing was held before a single judge, who ordered the issue of the writ. The treasurer then appealed to the full bench, and it was not until October 16, 1872, that the matter was settled and the bonds placed in the hands of the board.

October 18, 1872, it was voted to buy the pipe and fixtures of the Holyoke Water Power Company at a price not exceeding \$18 000. Judge Buckland was so strongly opposed to the measure that he insisted on having his dissenting vote placed in the records.

Holyoke became a city in January, 1874, and the term of office of the old board expired by limitation at that time. The first board chosen by the city of Holyoke consisted of Judge Buckland, elected for three years; Dennis Higgins, for two; and J. G. Smith, for one year. It organized with Judge Buckland as chairman, and held its meetings in Lincoln's Block, having secured an office there at a rental of \$12.50 per month. When the City Hall was finished in 1876, the Board of Water Commissioners had the honor of being the first department of the city government to take up its quarters there.

The legislative act of 1872 permitted the use of the Tannery Brook, but no action was taken in this direction for several years. In February, 1877, the water of the ponds reached its lowest point, being 3 feet 9 inches deep at the gate house, and a water

famine seemed imminent. In view of this fact, the board in its report of December, 1877, called for early action on the part of the city council to make the waters of Tannery Brook available. This recommendation was repeated with increased earnestness in the reports of the next two years. But the city council was unmoved. The year 1880, however, was very dry, and it became necessary to pump water from the large pond to the smaller. Then at length the city council made the necessary appropriation, and in 1881 a dam and gate house were built and a 10-inch main laid to its connection with the 16-inch main from the ponds. This, it was calculated, would deliver 226 000 gallons each twenty-four hours. In order to keep the water of the brook from pollution, the board purchased of A. Goodyear "the entire Bagg farm, with the buildings situate thereon, with the right and privilege to forever divert the waters of the brook and use same for the benefit of the city."

But meantime the needs of the city had increased to such an extent that in the very same report in which they announced the taking of Tannery Brook, the commissioners petitioned the city council for "authority to take the necessary steps for securing a foothold by purchase or otherwise, for the diversion of any or all water courses that in their judgment are practicable to the use of the city as an additional water supply." In its last meeting of the year, the council gave the authority asked for, and the necessary permission of the Legislature was obtained at its next session.

The point immediately in view was the Whiting Street Brook, and the board took prompt action to construct a reservoir there. A substantial stone dam was built, 141 feet long, 7 feet thick on top and 12 feet at the bottom, with 15 feet at its extreme height above bed rock. The work was completed by deepening the channel of the brook, cutting and clearing away from its banks the brush for a distance of two and one half miles from the dam, and enclosing about two acres with a barbed wire fence.

The new reservoir, which is thirty feet higher than the ponds, and has a flowage area of one acre, furnished enough water for the needs of the upper part of the city, except for a few weeks in mid-summer. Besides, the greater head from this source largely in-

creased the efficiency of the Fire Department. In the winter of this year there was a great deal of trouble experienced from the freezing of pipes, and the whole available force of the board was employed in thawing them out. In March, the frost drill, which had been used for a short time in 1875, was again employed, and, with an improvement suggested by Superintendent Hardy, was very efficacious. A full description of this simple but wonder-working contrivance may be found in the report of the commissioners for 1885.

The next year, 1886, saw carried out the original plan of having two independent lines of pipe from the ponds, at a cost of twenty-one thousand dollars. In 1888 preliminary steps were taken for building a storage reservoir on the Whiting Street Brook, as had been contemplated from the beginning. The necessary land was taken, plans drawn, and the contract for building the dam awarded to Delaney Bros. This work was nearly completed in 1889, and put into use the next year.

The dam was "built of hard, close-grained sandstone, pointed and grouted with Rosendale cement. The earth under the dam for 1 000 feet of its entire length is a very compact and unyielding, gravelly hard pan; for the remaining distance the dam rests on a rock foundation, and here benches were cut, deepest on the water side, to connect the structure more closely with the foundation. The length of the dam is 1 773 feet, and its greatest height 21 feet above the natural surface." The reservoir has a flowage area of 114 acres, a watershed of $1\frac{1}{2}$ square miles, and a capacity of 500 000 000 gallons, all available.

The summer of 1891 was exceedingly dry, and although, in April, the ponds and the new reservoir were full to overflowing, the waste water of the latter running away in a stream 17 feet wide and 6 feet deep,—and this for several weeks,—by September 1 street sprinkling had to be discontinued, and by the middle of December the water at the gate house at Wright's Pond was 5 feet 5 inches deep or 5 inches only above the danger point, or what is considered the danger point. Hence we are not surprised to find this statement in the report of the board dated the same month: "This year's experience shows us that with our reservoirs full of water in the spring, we cannot pass through an extremely dry

summer without approaching dangerously near the limit. And if the reservoirs should not fill during the winter and spring, and the next season should be dry, a contingency not at all improbable, our condition would be extremely critical."

The very next year the contingency alluded to was upon us. The amount of water in the reservoirs was unusually small, and exceedingly vexatious conditions existed throughout the year. The use of hose for watering lawns, washing windows, etc., had to be entirely prohibited. This led to an immediate movement towards procuring a new supply. Various places were visited and examined, and opinions solicited from distinguished engineers. No less than seven different plans received more or less consideration.

1. An enlargement of the present supply by an increased storage capacity.
2. Bringing the waters of Hampton ponds into the Ashley.
3. Filter galleries or wells along the bank of the Connecticut, and pumping into Ashley Pond.
4. Building a dam on Bachelder's Brook in Granby, and pumping by water power into Ashley.
5. Pumping water from Willimansett Brook directly into the city pipe.
6. Driven wells on the sand plains of Chicopee.
7. Munn Brook, with conduit connecting into Ashley and a storage reservoir at Granville.

Time and space will not permit dwelling upon all these plans, which are fully discussed in the admirable report of Engineer McClintock to the board, which is published in connection with their report of 1893, but one or two cannot be passed over. To the use of Hampton ponds there were three objections:

1. An analysis of the water by the State Board of Health showed it to be far below the average in purity.
2. Ashley is about seventy feet higher than Hampton, which would make it necessary to pump all the water used.
3. The area of the watershed is quite limited.

In regard to the Bachelder Brook scheme, it was found that the surface of a pond raised by a forty-foot dam would still be one hundred feet lower than Ashley, so that all the water would have

to be lifted one hundred feet, which, of course, would require several gallons of water passing through the wheel to lift one gallon into Ashley. The other projects, except the last, were objectionable either on account of the cost of maintenance or the limited or uncertain nature of the supply.

So by process of elimination, the Munn Brook was left. At the same time, Mr. James L. Tighe, who commenced to serve the board as its engineer in June, 1892, and whose services have been invaluable from that day to this, presented a most interesting report, which amounted to a demonstration that the Munn Brook project was not only feasible, but would be an almost ideal solution of the city's great problem.

In accordance with the views of the engineers, a petition praying for the right to take said waters was sent to the Legislature. Strong objections were entered on the part of Westfield, and, after an extended hearing, the matter was referred to the next General Court, which finally gave the decision against Holyoke.

While this question was still in abeyance, another dry summer, 1894, put in an appearance, and in August, as the reservoirs were becoming very low, the State Board of Health was consulted as to the advisability of pumping water from the Connecticut directly into the pipes from the Whiting Street Reservoir. The chief engineer reported that in his opinion it would endanger the health of the community, and the project was dropped.

Disappointed, but not disheartened, by the failure to get Munn's Brook, the board soon turned its attention to the southwest branch of the Manhan River, at Southampton. This rises in the town of Westhampton, and flows in a southerly direction, passing Southampton, to the northern boundary of Westfield. Here it takes a very sharp curve to the northeast, passing close to Southampton Village, and thence towards Easthampton, within a mile of which it unites with the north branch, the two forming the Manhan River, which flows into the Ox Bow of the Connecticut River. The report of Mr. Tighe, recommending this plan, shows very clearly what was afterwards done. "The scheme proposed is," he says, "to divert the head waters of the southwest branch of the Manhan River, at the point of confluence, or a short distance below it, of the Manhan and Tucker brooks,

and convey them into Ashley ponds. The elevation at the proposed point is 115 feet higher than high-water mark at Ashley, or 325 feet higher than the Holyoke dam. With this head of 115 feet, a clean cast-iron pipe, 20 inches in diameter and $10\frac{1}{2}$ miles in length, will convey 4 750 000 gallons per day, or 3 750 000 when incrustated, thus having a discharging capacity sufficient to increase our daily supply to 6 500 000 gallons per day, or, in other words, to render a sufficient supply for Holyoke under normal conditions for twenty-five years."

This time the Legislature was favorable and granted the prayer of the commissioners, though the rights of Southampton were fully protected by Section 5 of the enabling act, which reads: " Provided that the city of Holyoke shall, when constructing its pipe line through the town of Southampton, place a " Y " branch in said line not less than 8 inches in diameter, at such point as may be designated by the selectmen, and whenever the town of Southampton shall vote to construct water-works, it may connect its pipes with that of Holyoke, and draw not to exceed 125 gallons daily for each inhabitant, without expense to said town."

By August the plans had been determined upon and a contract made with Fred S. Ley, of Springfield, to construct an intake reservoir with an earthen dam having a concrete core, and the work was nearly completed before cold weather set in. Under the contract was included "cleaning and grubbing the reservoir and dam site, and removing whatever might endanger the permanency of the work or the purity of the water." The total length of the dam is 900 feet from its extreme end to the overflow. Its width is 15 feet, with a slight crown in the middle.

In connecting this reservoir with the ponds, great care was exercised in selecting the course of the pipe, so as to obtain the best possible result from an economical as well as from the engineering standpoint, and all bends and curves, both horizontal and vertical, were laid with radii not less than one thousand feet. So skillfully were the plans laid and the details attended to, that the whole line was constructed of straight pipe 12 feet in length, without a single special casting. So far as we know, it is the first cast-iron pipe of its length and size in this country with all its bends and curves laid with radii of such length. The work was

completed early in 1898. The reservoir was christened "Fomer," and on May 4 of that year water was for the first time let through the entire ten and a half miles of pipe.

The results of this new addition to the city's water supply were at once apparent. The next year, 1899, furnished the longest and driest dry season since the inception of the water works, and, while other cities and towns were full of anxiety and resorted to great expense to avoid serious calamity, Holyoke moved on her way with perfect serenity, having an abundant supply of wholesome water.

Our water supply was now almost ideal, except in one particular. In quantity, quality, and wholesomeness, it was all that could be desired. But its pressure was not sufficiently great to secure ample fire protection in all parts of the city. The board, not stopping to rest upon the laurels already won, at once set out to obtain the required pressure, and thus make the supply a model one in every respect.

Three plans were considered by Engineer Tighe, all of them practicable:

1. A direct high-service system, by cutting off from the main-pipe system that portion in which a high service is desirable, and establishing a high pressure by power, that is, by pumping from Ashley or Whiting Street Reservoir directly into the pipes, in which the pressure could be regulated by the power of the pumps;
2. To pump into a standpipe or reservoir located on Crafts Hill, from which the pressure would be furnished by gravity; and
3. To build a high-service reservoir on Tatro Brook, one of the principal feeders of Ashley.

The last plan seemed the best from every point of view, and was adopted. The task of preparing the basin for the new reservoir was a gigantic one. It was commenced in 1899, laid aside for two years, and taken up vigorously again in 1902. Besides a great amount of underbrush, there was an almost endless array of stumps,—some 12 000 by actual count,—making a pile, after they were dug out, from 50 to 100 feet wide and 15 feet high, extending the full length of the reservoir. After they had succumbed to fire, there were twenty acres of muck to be dealt with, and thousands upon thousands of loads were dumped into

a convenient ravine. Below the muck was a gravelly subsoil, then clay, and below this another layer of sand.

The dam is 1 600 feet long and 35 feet high at the gate house. It has a uniform width of 25 feet on top, with a 15-foot roadway, with grass on either side and on the outside slope.

The entire work, both of preparing the reservoir and constructing the dam, has been done by the Water Department, under direction of its engineer, Mr. Tighe.

The area of the reservoir is 65 acres, and its capacity some 350 000 000 gallons. Its height above Ashley overflow is 108 feet. Its entire cost was about \$130 000. The masonry core wall cost a little less than \$6.00 per cubic yard, the embankment 60 cents and stripping and grubbing 40 cents per cubic yard.

A few points have been passed over or merely alluded to in the above historical survey which merit more consideration.

The policy of the Water Department in purchasing land so as to control the watersheds has been considerably criticised at times, but the far-sighted wisdom of the course is now generally acknowledged. Similar policy would have saved one of our sister cities much of the trouble and inconvenience with which she is struggling to-day.

The water commissioners have made a special point of looking after the cleanliness of the property bordering on the ponds. It is regularly patrolled by men of the department, and great vigilance is exercised in protecting the waters in the reservoirs from all pollution. Careful consideration has been given to the beauty of the surroundings also, and now the entire system presents somewhat the appearance of a series of parks, where everything unsightly has been removed, and every attention given to beautifying and making attractive.

In 1874 meters were placed in each manufacturing establishment using city water. The rates established were said to be lower than in any other place in the country, that for the smallest monthly use being one half and for the largest use one sixth of the rates of Boston, Cambridge, Providence, and New York. It may be remarked also that the ordinary water rates are the lowest of any city in the Union, the rate per family being \$3.60 per year. While the policy of installing meters generally throughout the city

has been the subject of more or less discussion privately, it has never been formally considered by the board.

It may be noted here that since the opening of the Fomer Reservoir accurate measurements have been taken daily, so that the exact amount of water passing into the main is known, as also the amount yielded by the watershed, the results tallying very closely with the calculations of Engineer Tighe before the reservoir was in existence. And the department is now placing two 16-inch meters, made by the National Meter Company of New York, and two Venturi meters, one 16-inch and one 24-inch, for the purpose of measuring accurately all water coming into the city.

The mains are controlled by valves placed at each cross street. All service pipes from the main to the curb are controlled by the Water Department, who have recently adopted the tin-lined pipe.

It has been the policy of the board to put in 6-inch, two- and three-way hydrants at intervals of five hundred feet. A valve is placed in the hydrant pipe, between the hydrant and main, for protection. These hydrants are in charge of the Water Department, and one man is assigned to the special duty of looking after all public hydrants. He attends all fires and sees that the hydrants used are properly closed. No one is allowed to use or touch a public hydrant without permission of the department, and all such use is under the supervision of the superintendent.

By a special act of the Legislature in 1901, the city was allowed the right to tax the property of the Water Department, upon its construction, at the regular rate of taxation for private property, and the department in turn charges each municipal department for all water used, the Fire Department paying an annual rental of eight dollars per hydrant. This law was petitioned for by the mayor and water commissioners jointly, and became operative in 1902. Its motive was found in a somewhat general feeling that the Water Department, being a successful and prosperous business enterprise, should bear its share of the municipal burden. Its operation has caused a noticeable diminution in the amount of water used in the public buildings.

There is one feature in our pipe system which must be of some interest, at least to the uninitiated. It is where three pipe lines, namely, two 16-inch and a 24-inch line, are fed by a single 20-inch line.

As already stated in this paper, the original pipe line from Ashley Reservoir was built of two sizes of cast-iron pipe,—20 inches in diameter for the first 1 600 feet and 16 inches for the remainder. The larger size was laid through a hill 1 300 feet in length, where a great part of the excavation was over 50 feet in depth, and considerable of it was rock. The carrying capacity of this line was sufficient for the requirements of the city until the year 1886, when a second 16-inch line was laid from the end of the 20-inch main to the city.

As the years went by, the pressure in the business centers of the city gradually decreased, until, in 1900, it was only 25 pounds at the City Hall, where it was formerly 45 pounds. The situation was becoming rather serious and demanded prompt attention. The laying of another pipe through the 1 300 feet or so of hill would be an expensive and difficult work, especially since the excavation for the first pipe line was not made wide enough for a second pipe, and, besides, the trench excavated was practically all refilled. To overcome this difficulty and save expense, the proposition was advanced by the Engineering Department that if a third pipe line, 24 inches in diameter, was connected at the end of the rock cut, so-called, with the 20-inch pipe in the same manner as the two 16-inch lines, the pressure would be increased at least 20 pounds. The proposition of having a 20-inch pipe feed two 16-inch pipes and a 24-inch pipe, and increase the pressure besides, could not but appear absurd to the lay mind. However, the water commissioners were finally convinced of its practicability. The 24-inch pipe line was laid, and the correctness of the proposition demonstrated, as the pressure was increased at once by an average of 22 pounds, bringing back the pressure at the City Hall to 45 pounds.

One matter which may not be passed over in a paper of this kind has not yet been alluded to. In common with many other places, the board has had a long and perplexing fight with the unpleasant odor and taste which occasionally characterized the water. This first began to be noticeable in the fall of 1875, though tradition has it that back in 1847 or 1848 Wright's Pond was badly affected, and its waters even discolored. But in October, 1875, the water commenced to have a fishy taste, and to emit

an offensive odor when boiled. It rapidly grew worse. "Eel juice" was its common appellation, and the term sufficiently describes it. A thorough flushing of the mains was resorted to without effect. Then, on the theory that the cause might be found in the swampy bottom of a part of Wright's Pond, the water of the latter was drawn down as low as possible, and the pure water of Ashley admitted. This made no appreciable difference. Samples of water taken from different points in the two ponds, and also from house faucets in the city, were submitted to Professor Goessmann of the Massachusetts Agricultural College, who had made the original analyses for the Water Supply Committee. He reported that there was no material difference in the samples, and that the chemical analysis showed practically the same result as in 1872. About the end of March the offensive taste and odor suddenly and mysteriously disappeared after a stay of five months, during which neither the most careful microscopic examination nor chemical analysis revealed the presence of any disturbing or noxious element in the water, and it is by no means certain that any of the measures resorted to for the purpose of mitigating or removing the evil had any effect whatever.

In February the ponds were visited by Professor Nichols of the Massachusetts Institute of Technology, who was then employed in investigating the peculiar condition of one of Boston's reservoirs. In his report, while mentioning several theories that seemed more or less plausible, he said, "I do not feel that we possess sufficient evidence as yet to justify us in adopting any theory." The trouble recurred at intervals, but in 1880 was worse than ever before. The local paper teemed with essays from indignant citizens on, "What Ails our Water?" and kindred subjects, while its columns were largely used by engineers to lash each other's pet theories. The assurance that whatever the trouble was, it did not impair the healthfulness of the water, did not seem to satisfy people in general, and the lives of the water commissioners were made a burden to them. In their perplexity they consulted distinguished engineers, among them Mr. J. N. Tubbs, chief engineer of the water works of Rochester, N. Y. In his report he expressed a belief that the trouble was caused by the "disintegration and death of microscopic plant organisms which, at a certain period of their

growth, become detached from stalk or bottom, and for a time remain suspended at or near the surface of the water." He recommended, therefore, the extension of the main pipe several hundred feet out into the pond, to where the water is thirty feet deep, and also that when the water was low the exposed bottom should be covered with gravel. Engineer Herschel was also consulted, and made recommendations. However, on account of the acknowledged uncertainty as to the cause, no action was taken towards carrying out any of the recommendations.

In the spring of 1902 there was a fresh invasion of the old evil, the disagreeable taste and odor appearing in full strength. The hydrants were opened and the mains flushed at intervals, both in the day time and at night, but without apparent effect. Finally, by invitation of the commissioners, the State Board of Health came to Holyoke and investigated. Their conclusion was that already reached by Engineer Tighe, namely, that the principal cause of the evil was *Uroglena*, microscopic animalculæ, which for a long time were classified as plants. The cause of their sudden appearance and disappearance is still an unsolved problem. The Water Board of Holyoke, accepting this theory, and finding, after careful testing, no traces of *Uroglena* in the Fomer, Whiting Street, and Tannery reservoirs, made a new arrangement whereby, when the *Uroglena* appear, the offending pond can be cut-off from the mains and sent to the hospital, as it were, until it recovers. Thus they believe they have won the long fight, and that the unpalatable condition of the water will soon be but an odorous memory.

The flowage area of the reservoirs now in existence, including the high-pressure reservoir, is 475 acres. The area of the watersheds of Ashley, Wright's, and Whiting Street is $4\frac{3}{4}$ square miles and their available storage capacity is 1 700 000 000 gallons. This is a large reservoir development, and makes available a daily yield of 900 000 gallons for each square mile of watershed. Practically speaking, it makes available almost the entire total yield of the watersheds, and further development on these sheds might be well questioned from the standpoint of economy.

The watershed of the Fomer, which has an area of 13 square miles, has several sites for large storage reservoirs which, when de-

veloped, will furnish a daily yield of 10 000 000 gallons. At present there is only an intake reservoir of 17 000 000 gallons capacity. About $1\frac{1}{2}$ miles above this intake is a site for a storage reservoir, where a dam 50 feet high and 200 feet long will impound 750 000-000 gallons on an area of 131 acres. The development of this reservoir, or one of the others on the watershed, will command the attention of the water department in the near future. This will make available from our watersheds, with an area of $17\frac{3}{4}$ square miles, a yield of 14 000 000 gallons per day, or a quantity sufficient, allowing 100 gallons per capita, to supply a population of 140 000.

The water supply of Holyoke is now a model one. There is an abundance of pure, wholesome water for all the needs of the present, and plans have been definitely laid to meet the exigencies of the future. It stands to-day a lasting monument to the wisdom, energy, integrity, and skill of those who have had it in charge.

BOG FUEL.

BY EDWARD ATKINSON, PRESIDENT BOSTON MANUFACTURERS'
MUTUAL FIRE INSURANCE CO., BOSTON, MASS.

[September 15, 1904.]

Mr. President, — I never get over the sense that it is a sort of gigantic joke for myself, who never had any scientific training of any kind, to get up before you gentlemen and discuss or present hypotheses which I have dug out of my own inner consciousness, — in this case having mud on the brain. But when one gets pretty near eighty he can afford to lay aside all his native modesty and tell what he thinks he knows, and, by putting it before gentlemen who do know, find out for himself whether what he thinks he knows is based on fact or not.

I greatly feared that I should be unable to be here, and therefore I jotted down a very short statement of what we have accomplished in laboratory practice. And here again you all know how dangerous it is to put hypotheses into commercial practice on the basis of the laboratory. Many things can be done in the laboratory that do not pan out when you attempt to apply them commercially. With this qualification I will tell you what we have done since I presented the visionary aspect of this subject before you last year.

The experiments on the contents of many bogs have been continued since that meeting, and what then seemed to be a somewhat visionary proposition may develop into burning facts.

The quantity of coal in its primary form, underlying great cedar swamps and bogs covered with grasses, containing very little moss, can be converted into briquettes in a small machine which would correspond to a magnified meat-chopper, a diagram of which I have here, at the rate of ten tons, dry weight, per day of ten hours, with one horse-power for the operation of the machine. This machine can be supplied on a large scale at \$50 and singly at about \$75.

It is a development of the original machine which I happened to invent in 1866-67, when, coal being \$12 a ton in paper money prices, we developed a moss peat bog. Keep in your minds the distinction between the sphagnum moss or ordinary peat bogs and the grass peat bogs to which your attention is mainly called. I invented a little machine which, fortunately, I patented, and that worked for many months and fed our boilers for a 30 000 spindle mill with the product of a moss peat bog worked through this machine. I did not know what I was doing then; now I know. When coal got back to \$5 a ton, we dropped the use of the machine, and I sold it or gave it to Nathaniel W. Farwell of Lewiston, and he worked it at Lewiston for a longer period. I am rejoiced that that original machine has been found stored away in a barn, and it has been rigged up and is working again in its rough, crude way. The machine which Professor Norton and I have now constructed is simply a development of that machine, and I say I fortunately patented it, because I find that all the European machines in which this practice has been extended on different kinds, mainly of moss peats, are simply counterparts of rather a complex and expensive kind. Efforts which have been made to get patents in this country and to hold the bottom patents are cut off entirely by the existence of my old patent which has expired; and step by step, as fast as we think we learn anything, according to our common practice, we immediately publish it, so that there is no possibility of any monopoly or any bottom patent on any part of this work. There may be, and I hope there will be, many devices, modifications and patents, for as in the case of many such inventions, there are forty different ways of doing the same thing; and I would not give a rap either for any patent that can be issued hereafter on the conversion of this material into gas, for all the principal gas patents have expired on any mechanism which may be patented for the work.

The calorific value of the briquettes varies according to the kind of plant growth from which the carbons and hydrocarbons have been derived, and somewhat according to the depth and age of the mud; perhaps seventy per cent. of the calorific value of average gas coal would be a conservative estimate. When the

hairy vesicles in which the hydrocarbons are contained, and which I suppose to have been originally the veins by which the juices of the plant were conveyed, are broken in the machine, this adhesive hydrocarbon spreads through the mass, making a briquette that can be easily handled. Dried in not less than four weeks in the shade, it condenses itself without compression, coming down to a water content of probably 15, possibly 20, per cent., in hygroscopic form.

In the mud from a bog in the southern part of Brookline, about a mile and a half from my own house, which was worked on my lawn at a meeting of the American Academy of Arts and Sciences, the proportion convertible into gas is a little in excess of 46 per cent., as against 36 per cent. in the best Westmoreland gas coal. Here are samples made on the 8th of June in a little machine which I set up on my lawn. At the same time I had some briquettes made from miscellaneous mud, about four weeks old, which I placed in the open fireplace in my library,—fortunately it was a cold, easterly day, — and set on fire with some kindlings at half past four. They burned with a hot fire, free of smoke and soot, giving a delicious peaty odor to the atmosphere, until half past ten, when they were entirely consumed. This material would burn on a grate in the open without any artificial draft. I also had a glass jar receptacle, under a water seal, of illuminating gas made from the same material, with a gas burner attached, which I lighted in the parlor and showed to my scientific friends, afterward inviting them to partake of an afternoon meal or supper cooked in the Aladdin Oven. (Applause and laughter.)

I suggest to the members of the Association, whenever dealing with a deposit of this modern coal, to bear in mind that all coal has once been mud partially or wholly coked under pressure by internal heat. You will bear in mind that when vegetable matter falls into water the anaerobic microbes, which live on the albuminoids, consume the albuminoids, and then, when they die, they are converted into gas and make the marsh gas, the will-o'-the-wisp which Tam O' Shanter ran away from. I am the modern Tam O' Shanter running after them. (Laughter.)

The carbon is retained in the form of fixed carbon and the hydrocarbon in the vesicles combined with water. We may

have substituted a simple little mechanical contrivance for doing the same thing which geological ages do in the conversion of mud into — what is it? Coal? Call it what you please; I call it bog fuel.

I would advise you all to procure a large-sized meat-chopper, work the mud through that, form it into briquettes in a biscuit pan and put it down in a corner of the kitchen to dry off, and see what you have. If you want to make some coke, take an iron kettle, put your briquettes in it, fasten on a tin cover, make a little hole in the cover with an awl, set the kettle on the stove and heat it to a red heat, set the gas on fire after the steam has passed, and when the gas ceases to burn take the kettle off, and, of course, let it cool off without removing the cover so it may not take fire, and then find out what you have. You will find some coke. One of my correspondents in Iowa has written to me that he bought the largest meat-chopper he could find, and made a ton of first-class household fuel in that way, without coking it, at the rate of six pounds per minute. In about five hours he had a ton which he says met all the conditions of the best household fuel.

All the work that we can do in the laboratory is ended. Our final report will be made very soon, now that Professor Norton has returned from his summer vacation. If these facts which have been developed in the laboratory can be justified in commercial practice, this spells evolution and perhaps revolution. I have brought here my two reports already published, one on mud fuel and the other on bog fuel, and two copies of diagrams of the machine. I will supply copies of these reports, and of our third and final report when it is issued, to any one of you who will send a postal or will call at my office, 31 Milk Street, Boston. I have there a museum collection of the products of bogs in Europe; although, as I told you last year, this originated accidentally in my own mind when I was riding through Bristol County, by the bogs, to my summer place. Thinking about compressing corn-stalks for fuel, and looking out on that great area of bogs it suddenly occurred to me, "Why, all that stuff is carbon. Will mud burn?" I found it would. There are as yet no recorded data by which the number or area of these bogs can

be determined. They have always been looked upon as waste, worthless, and to be bought in any quantity at \$5 an acre. If members of the Water Works Association will give me information of a general kind, as to the place, approximate area, depth and surroundings of such deposits, it will be very serviceable.

While we shall presently make a final report of laboratory practice, giving way to the commerical undertakings that are now being entered upon, we shall still continue our investigations and tests in respect to the quality of the different deposits, and yet more to the analysis of the gases and the separation of the secondary products, one large element of value in which will be wood alcohol. We therefore invite wide correspondence, and you may ask any question by mail, or send me a kegful of the material at any time, and without going to the expense of an analysis we can tell you whether it is promising or not. If you desire to have it worked and find out its calorific value, of course, as the Insurance Engineering Station is not a charitable institution, but depends upon voluntary contributions for its support, we must make suitable charges according to the amount of work which may be done. I invite your coöperation in the development of this subject, if you find it expedient to join.

I should say that there is nothing new under the sun, and although this idea originated in my own mind, yet, like every other idea that comes to thoughtful men when an emergency comes upon them, other people had been seeking for emergency fuel, and moss peat fuel as a substitute for coal had been used in many parts of Europe before I thought of it. Singularly enough, the very month in which I had begun to work there appeared an article in the *Fortnightly Review* by a retired general of the British army, dealing with the great bog of Arran in Ireland, and predicting that that bog would become the source of energy by which the manufactures of Ireland could be restored; and they are now working that bog on lines similar to those that we are working on, and I am in correspondence with the engineer.

It also appeared that in Sweden they have bogs which, so far as I can learn, are mainly moss and are not equal to ours in quantity, depth or quality. And yet Sweden has become practically independent of English coal, and a most thorough and

scientific report has been made by the Swedish government, giving the details of the development of bog fuel throughout Europe. In memory of this some of the dried and prepared bog fuel has been reduced to a powder and then compressed. You cannot compress it in its natural state, or except at a very heavy expense which precludes compression. You will bear in mind that it condenses itself when the hydrocarbons are released. It then begins to shed water and dries down naturally to a density of about the specific gravity of coal, and in some cases to the specific gravity of coal. And I have a sample of mud from somewhere in Michigan, of which there is not a very large quantity, and which the discoverers are buying up, which is heavier than anthracite coal and burns without leaving any ash whatever. Whatever is left is so fine that it goes off. Some of our bog mud leaves about 6 per cent. of pure silica. That probably consists of the diatoms, which are the skeletons of the protoplasms that live on the stalks of sphagnum moss and make the great deposits of earth which are found in the ordinary peat bogs, or else it is silica from the grass. It runs up from 6 per cent. of ash to 16 or 17, where there are brooks or rivers which occasionally bring in silt, and then the ash will not be entirely pure silica. As I said, in Sweden they have ground up this material and then compressed it and have issued a medal made of it. Here is a medal, with King Oscar's face on it, in memory of the independence of Sweden from coal for ordinary purposes.

I will first pass around the samples of bog fuel made on the 8th of June on my lawn from a barrel of mud which was dug rather close to the shore. It contains 16 per cent. of ash, and has about 70 per cent. of the calorific value of coal in thermal units. That yields 46 per cent. volatile as against 36 per cent. for the best gas coal.

Our first experiments were made upon the mud of a great cedar swamp which lies between Easton and Taunton. From all I can learn there are about 20 square miles in that swamp; it is of very irregular form, and in many places it is 40 feet deep. Oliver Ames explored it many years ago with the idea that it might be drained and the water table reduced, and he came to the conclusion that the average depth of the mud was 25 feet.

Now, if there are 20 square miles 25 feet deep, there are at least 200 000 000 tons, dry weight, of this fuel in that one bog. It is of a higher calorific value than the Brookline mud, and it probably contains an equal or greater quantity of volatile. There is a specimen of it air-dried, without the breaking of the vesicles of hydrocarbon in the machine. Here are samples of the briquettes, which were originally about double or three times the section, showing how it, as you may say, compresses itself when dried in the proper manner.

After the Brookline experiments I placed a lot of the briquettes on boards out on my lawn, where they were exposed for two weeks to the hot sun in a period when there was very little rain, and it proved that they dried too quickly. These are friable and could not be handled, so I have not been able to keep a whole briquette. The stuff emerges from the orifice of the machine in a section of about twice or three times that, and is hard enough to be handled and be set up cob-house fashion perhaps two or three deep, which will require less space for drying; but I found that this dried in the hot sun was too friable and remained somewhat porous. Here is a sample of the same material dried more slowly in the shade. This sample was dried on a table in the basement of the Institute of Technology for four weeks, when it was ready to burn.

Here are samples from the great cedar swamp, — the original in the air-dried condition, and after the working. That is better and richer than the Brookline deposit.

To go on further with the European practice, — I have samples at my office which I should be delighted to show you, — in Holland the Dutchmen are converting the grass mud in their own meadows or “polders” into fuel for domestic purposes by treading it out with their wooden shoes on. They are working it commercially for sale at a cost of 90 cents a ton.

The principal experiments in Germany, where millions of tons are sold, are on the high moss peats. It appears that in Denmark and all over Europe certain mosses or heathers are found, as in Scotland, which can be worked and are converted into briquettes and make a valuable fuel, and that is sold at \$2.50 a ton. There is no way of comparing costs, because it is made in countries

where wages are very low and by processes in which there is a great deal of hand labor. It will remain for us to invent simpler machinery as we have here for working the peats, and to substitute carriers and mechanism for the so-called cheap labor of Europe, which is very dear labor in point of fact.

In Russia the work has become so important that the government in its customary manner has appropriated all the bogs and put a heavy license tax on in order to get a revenue, for the big war which they are now carrying on, out of the poor, miserable peasants.

In Prussia and in Austria the briquettes are sometimes mixed with waste coal, and they are made in various ways, and they are used by locomotive engines and steam plants and for a great variety of purposes.

In eastern Prussia there are large deposits of copper pyrites which have been worked for the sulphur, the residuum containing about twenty per cent. of copper, hitherto so friable that no method had been found for smelting it; but now they mix it with mud and make it into briquettes strong enough to stand the smelting process, and they are now recovering the metal.

Before I went to that I ought to have shown you some of this coke. Here is a sample of coke made from mud found near Hartford, Conn. There is rather too much silt in it, but you will observe that it is excellent coke. This has attracted the attention of our clients in Connecticut who work brass. They have heretofore been obliged to use charcoal and wood almost exclusively, because of the impossibility of finding any coal that would not contain traces of sulphur and phosphorus, — and sulphur and phosphorus make brass brittle. The coke made from mud is absolutely free from sulphur and phosphorus, and the brass-workers are about giving their attention to it, without much regard to its cost as compared to coal, but with regard to its cost as compared to charcoal; and I expect very great commercial developments from that. It is the purest coke which can be made.

In Europe, where they are obliged to avoid waste to an extent of which we are completely ignorant, they are also combining the waste sawdust with mud and making little briquettes easily

transportable for kindling. Every great pile of sawdust — and you know how many there are — is apt to lie near a bog back of the mill. All the slabs can be ground easily, and all that waste can be combined with the bog fuel, made into briquettes and converted into light fuel suitable for kindling and for many purposes.

The secondary products have been found to be quite valuable. Some of the high moss peats contain what is called cotton grass; I think we do not have it in this country. That yields a fiber which is now being spun and woven into blankets which are used in hospital practice, their sanitary virtues having been found to be very great; and there is a great variety of secondary products. Our own students who took this for their graduation thesis found it such a long and complex piece of work that they had not finished before their vacations, and the papers are not yet in my hands for publication, but they will be published presently in connection with the third and final report of our laboratory practice. There is a very large quantity of wood alcohol, there is paraffine, tar and tar water, and there are other more curious substances. There is an oil derived from it in Paris, which we know nothing about, which has peculiar properties, and what will come of that we know not.

I had thought of putting up a little commercial plant; for \$1 000 I could start a 20-ton per day plant in my own neighborhood. But both Professor Norton and myself desire to keep absolutely free, if we can, from any commercial undertaking, and to act judicially in developing what we can in the laboratory without any personal interest whatever except in the investigation and publication of the facts.

One gentleman who is thoroughly conversant with gas came in to see me the other day. He had already bought 1 000 acres of bog which can be drained, and that will be a great advantage in removing a considerable part of the water, but his attention having been turned to this he is now looking toward it not only for development in that way but for development for gas.

Mr. Loomis, the original inventor of the Loomis gas producers, is now the senior member of a very large corporation that has lately bought 600 acres of the old Cudahy yards near Detroit, I think, where they are putting up plants for the manufacture

of their gas-producing works and their gas engines. They have one of the types of gas engine which sucks the gas from the producer directly to the engine without any intervening gas holder. One of those plants of 80 horse-power has lately been started at Enfield, N. H., and is now in operation. As that interested me from the underwriters' point of view, I sent one of our best men up there to witness the start and the operation, to see if it were going to be any more hazardous from the fireman's point of view than a steam plant, and we came to the conclusion that it was no more hazardous and perhaps possibly less so. They are prepared to provide now gas engines of from 50 to 2 000 horse-power, on a guarantee of one horse-power per hour to one pound of coal. That is about one half better than the average practice, and is a tenth better than the best result ever attained in any steam engine within our knowledge, — that attained by Fitzgerald at the pumping station in Boston, — and equaled only in one factory that I know of, where in the Merrimac yard in the new plant they did work at a pound and a tenth. In other words, this mechanism will develop into power 25 per cent. of the calorific value of coal, as compared with the $12\frac{1}{2}$ average practice. That means a good deal.

Mr. Loomis having been attracted by one of my earliest reports, without coming to see me, for nearly a year made a thorough investigation on his own behalf to see whether this meant anything or not; and he authorized me to say that he had come to the conclusion, and was prepared to act upon it, that as a source of gas for power coal was not in it as compared to this fuel, where coal costs \$2 a ton or more; and in that estimate he used conservative figures which would be reduced by our laboratory figures to a comparison with coal at \$1.50 a ton.

Now, this is so incredible that I am trying to force myself not to believe it, for fear that when it is developed, or the effort is made to develop it commercially, some out will be found, and that it may fail, as so many other laboratory experiments have failed, when put into commercial practice. That is where we are. What we know is derived from our laboratory practice. My scientific friends are less incredulous about it than myself; but what a ludicrous joke it would be for a "duffer" like me to have

led the way over these oceans of fuel that all you scientific gentlemen have been passing by for so many years. (Laughter.)

This, gentlemen, is all that I have to say, but I will be glad to answer any questions that I am capable of answering; and I repeat that I could not bring, for I did not know how many of you would be here and I came hastily, big bundles of these papers; but all we know is in the two reports already made, or will be in what will be the final report of the laboratory development, and any of you or all of you who may send me a card, or better yet, come and see me and look over my one hundred specimens, more or less, of every type of fuel, and then let me take you through what I think is about the best organized lay-out of an office in the drafting room, the credit of which is mainly due to John R. Freeman, and incidentally to myself, I shall be happy to show you through the whole thing. (Applause.)

DISCUSSION.

THE PRESIDENT. Gentlemen, it is unnecessary for me to say that we have all been interested in what Mr. Atkinson has said, and I have no doubt he will gladly answer any questions you may see fit to ask.

MR. T. H. MCKENZIE. Isn't the odor from the peat fuel disagreeable, particularly if the fuel is used for domestic purposes? I have been but twice to a place where it was in use, and then the odor pervaded the entire house and it was quite disagreeable.

MR. ATKINSON. If you get too much of it, it may become disagreeable, but just the little whiffs you get out of a fireplace with a good draft give the most delicious woodsy odor, so that when Professor Norton has been at work in the basement and a little of the odor pervaded the building, everybody wanted a sniff of it. There is one caution I have given him, — that was, not to put a little still alongside of a bog fuel fire, for fear he will get a new flavor in the whiskey. (Laughter.)

MR. MCKENZIE. Several gentlemen sitting near me have asked as to the number of processes through which this material passes.

MR. ATKINSON. Simply what you may call the grinding process, and then it comes out in a continuous briquette, and we cut it off by hand; but it will be a very simple matter to have a little cutting machine.

MR. MCKENZIE. Is it under a high pressure?

MR. ATKINSON. No. If you compress it too hard it comes out cracked. The machine consists of a series of plowshares, knives and hooks, which break up the whole mass, and then there is an Archimedean screw which pushes it forward into a slightly elastic tube of the section of the briquette, and that comes out on little rollers, rolls out on a cloth, and the boys remove the briquettes. That is the only process except to remove them to the point where they are dried. There is no other compression than that of the Archimedean screw forcing the stuff out.

MR. MCKENZIE. Approximately how long does it take to dry?

MR. ATKINSON. Well, as I said, when dried in the sun two weeks, it was ready to burn, but it was too friable. When dried in the shade four weeks, it was good fuel, probably containing about 25 per cent. hygroscopic water.

MR. T. W. MANN. Is it a process of shrinking, after it comes out in that form, which brings it to this hardness?

MR. ATKINSON. Yes, sir. You cannot use the word "compression," but it consolidates of its own motion.

MR. MANN. As a bar of soap might dry out?

MR. ATKINSON. Just like a bar of soap drying, that is all. There have been no end of experiments, and there are a lot of bogus companies selling stock now. They attempt to dry off the material first, and then break it up and compress it, but that is very costly. There are a variety of inventions for applications of artificial heat to attempt to dry it faster, but I think they will all fail. There are a lot of little things yet to be developed, but pretty much all the efforts failed until this secret of the breaking of the vesicles was discovered in Germany, and they have given a specific name to the hydrocarbon. I think they call this adhesive hydrocarbon, which is released by the mechanical action, — pentogane. A New York engineer, Mr. Witherspoon, spent two years in the study of this subject, went over all Europe, and is now established in New York as the engineer of a regular

commercial undertaking on a small scale — nothing but cash, no stock for sale — at New Rochelle, N. Y.

The mud of the Dismal Swamp is of an entirely different character from the samples which I have shown, but it makes good gas fuel. The mud which we worked from there had been evidently overflowed, there was more silt in it, and we found cockroaches and beetles, and the mechanic who worked it said he thought, as it was very antiseptic and smelt so strong, that he might have worked up some fugitive colored gentlemen who had got lost in the Dismal Swamp. (Laughter.) We have also worked the mud from the Hummocks and the Everglades of Florida, and the mud of Iowa, which is outside of the glacial drift. These other deposits are in the hollows of the glacial drift.

REPORT OF COMMITTEE ON PRIVATE FIRE SERVICES.

[September 15, 1904.]

Mr. Robert J. Thomas, in the absence of Mr. F. H. Crandall, chairman of the committee, submitted the following informal report for the committee on Private Fire Services:

The committee have no written report to make, Mr. President, but they are at work on the matter referred to them. At the present time in Lowell we are making tests of different meters and devices for the purpose of measuring water for fire services. While there have been many tests of appliances for measuring water, this is probably the only test of any importance which has ever been made of devices for measuring water exclusively for fire purposes.

I assume that most of the members are familiar with the Tilden hydraulic device* which is designed to measure accurately small flows. It consists of a vertical valve on the main line, and a by-pass. The vertical valve acts automatically, and can be arranged so that at any given quantity of water it will open and allow the water to flow through the main pipe. Up to the time when the valve opens, the water flows through the by-pass and can be measured through any desired meter, the small flows being measured accurately. The apparatus tested at Lowell shows perfect registration on flows as small as a sixteenth of an inch. In fact all small flows such as would be likely to occur from a leaky joint or fixture, or from a pipe under-ground imperfectly calked, can be measured by this device. The one we are testing at Lowell is set so as to open the gate at a flow of 250 gallons a minute; that is, a common fire stream under our pressure causes the automatic valve on the main line to open. Delivering at the rate of 2 500 gallons a minute through a four-inch "Freeman" nozzle, the Tilden device showed a loss of pressure of about five pounds. So

* Described in the JOURNAL, vol. 18, p. 198 (June, 1904).

that from the two standpoints it seems that this device meets all requirements — that is, the loss of head is a minimum, and the accuracy of measurement on small flows is retained. Of course, above 250 gallons per minute, or whatever it is set to open at, you do not get any measurement, so when water is taken for any other purpose in large quantities, as well as for fire purposes, you do not get the measurement.

Now, what the committee would like to see is a device which would measure the small flows accurately and also measure the large flows, and at the same time cause a minimum loss of head. We do not favor anything on the main pipe which is going to reduce the flow of water and reduce the head so that the sprinklers in high buildings will not get sufficient pressure to operate them; but we do want a device which will measure the water on large flows as well as on small flows. It is understood by members of the Association that it is not the desire of water works people to charge for water for the extinguishment of fires, — rather it is the policy of all water works people, private companies as well as municipalities, to encourage the insurance companies in their fight to prevent losses from fire, and to furnish all the water necessary for the extinguishment of fires at the highest possible pressure. But we believe that concerns obtaining extra fire service ought to pay for it. We believe in giving them all the protection that we give other citizens, all the benefit of the general fire service, and doing everything we can in a general way, but if they want any special and extra fire service we are of the opinion that the city or water company should be recompensed for it, certainly to the extent of payment for the cost of such service, for the maintenance of the pipes, etc.

The Lowell Water Board is perfectly willing to make a test of all meters and devices sent by any meter company or by any manufacturer who has an idea that he has a machine which will do the work satisfactorily. We have a place well equipped for making tests. Those who have seen meter tests on a large scale in other places say that we have the best opportunity for doing the work that they ever saw. The plant is located in the pumping station, and the water used for testing is discharged into the pump well so that it is not wasted; we have a U-gage, a mercury

column, and every facility for testing large meters on large or small flows for loss of head and for accuracy of registration.

DISCUSSION.

MR. EDWARD ATKINSON.* The underwriters have had great difficulty in preventing obstructions of fire services, and I hope any device which may be tested at Lowell will be submitted to Mr. Freeman and to our Board. We are now in a fight which has extended to some of our risks in the West. I have just proved to the water commissioners of one of the principal western cities that any meters which obstruct or interfere with the fire service had better be thrown away and the city stand the loss, rather than to interfere with the fire protection of factories on which the whole community depends. To obstruct the fire service for the purpose of measuring a little water that may be stolen or leak is an act of economic suicide on the part of a factory city that allows it to be done.

MR. THOMAS. I will state, Mr. President, that it is the intention of the Lowell Water Board to have, later on, a special test, and invite the representatives of the underwriters, the meter companies and of the water works people. In what we are doing now we are somewhat in touch with Mr. French of the Factory Mutuals, and it is the desire of the committee of the New England Water Works Association not to favor any device on fire pipes that will obstruct the flow of water to any material extent. We are just as much interested in the success of our factories, and in encouraging them, as anybody could be, and the Water Works Association would be the last body of men in the world, I think, to do anything to interfere with the prosperity of our manufacturing industries. But we have not only to deal with the manufacturers in our cities, but we have to deal also with people who are not in the manufacturing business. There are other establishments which are not manufacturing anything — power stations, and establishments of that kind — which might use large quantities of water without paying for it. This is not aimed at the manufacturers at all. But if manufacturers get extra protection by laying pipes through

* President, Boston Manufacturers Mutual Fire Insurance Co.

their yards and have special facilities for extinguishing fires, it is certainly no more than equitable and just that they should pay for those privileges, just the same as anybody else would and just the same as they have to pay for other supplies. I do not think the cry of committing economic suicide and injuring the industries is fair or right.

MR. ATKINSON. The sealing of hydrants so that water cannot be taken without its being known has proved very satisfactory in New Bedford.

MR. T. H. MCKENZIE. I cannot see how it is possible to arrive at any just method of charging for water for fire services by metering it. There may be a great many places which, for instance, are built and arranged according to Mr. Atkinson's ideas, where they do not have a fire for ten years, and in such cases there would be no income to the water department whatever. I think the only just method of getting at a rental is by the sprinkler-head and by the hydrant or stand-pipe, or some such method as that, so that there would be a uniform price charged from year to year. Of course a meter might detect a little stealing of water, but really what we want to get at is what would be an equitable rate for a charge for fire purposes.

PRESIDENT BROOKS. I think, gentlemen, that the more you study into the question of private fire supplies and the varying conditions under which they are used in different sections of the country, the more you will come to the conclusion that you have one of the biggest problems on your hands that you can conceive of. I think the matter will be settled satisfactorily only when the insurance people and the water works people come together and realize that they are each acting for the interest of both.

MR. THOMAS. Just one word more. Mr. F. C. Kimball, who is a member of our Association, made the statement before the American Water Works Association, from figures which he had obtained, that the loss in water wasted through fire service pipes footed up in dollars and cents during the year to a greater amount than the fire losses of the country for a year.

THE EPIDEMIC OF TYPHOID FEVER AT ITHACA, N. Y.

BY GEORGE A. SOPER, PH.D., CONSULTING ENGINEER AND
SANITARY EXPERT, NEW YORK CITY.

[Presented September 15, 1904.]

Mr. President, Ladies and Gentlemen of the New England Water Works Association, — The epidemic of typhoid fever which broke out at Ithaca in the winter of 1903 deserves to be regarded as one of the greatest outbreaks of this preventable disease which ever occurred in New York State. In the typhoid history of the whole country there have been few epidemics which have exhibited a larger number of cases.

Sanitary experts who visited Ithaca at the time of the epidemic were unanimous in their opinion as to its cause. Many who are familiar with the epidemiology of typhoid have said that seldom, if ever, has the danger of an epidemic been so unmistakably in evidence beforehand. Speaking now, more than a year after the outbreak, and with an intimate knowledge of the situation, it is difficult to understand why the city was not alive to the necessity of taking steps which would have rendered life and health secure. Apparently the people of this university town neither knew nor cared any more about the teachings of sanitary science than do the inhabitants of the scores of other cities in which epidemics occur. They were blinded to the dangers of the situation by the seeming healthfulness of the city's site, and so failed to establish those sanitary safeguards which are indispensable to every growing community.

STATISTICS OF THE EPIDEMIC.

The consequence of this mistake was terrible. With a population given by the last United States census as 13 156, it is estimated that 1 350 cases of typhoid occurred, with 82 deaths, in little more than three months. No less than 522 homes were visited by the disease; in over 150 of these there were two or more persons attacked.


The onset of the epidemic was gradual. A few cases first occurred in all parts of the city. Later it was observed that there were more cases in the section occupied by the students of Cornell University than in any other. There were, at this time, connected with Cornell about 3 000 teachers and students.

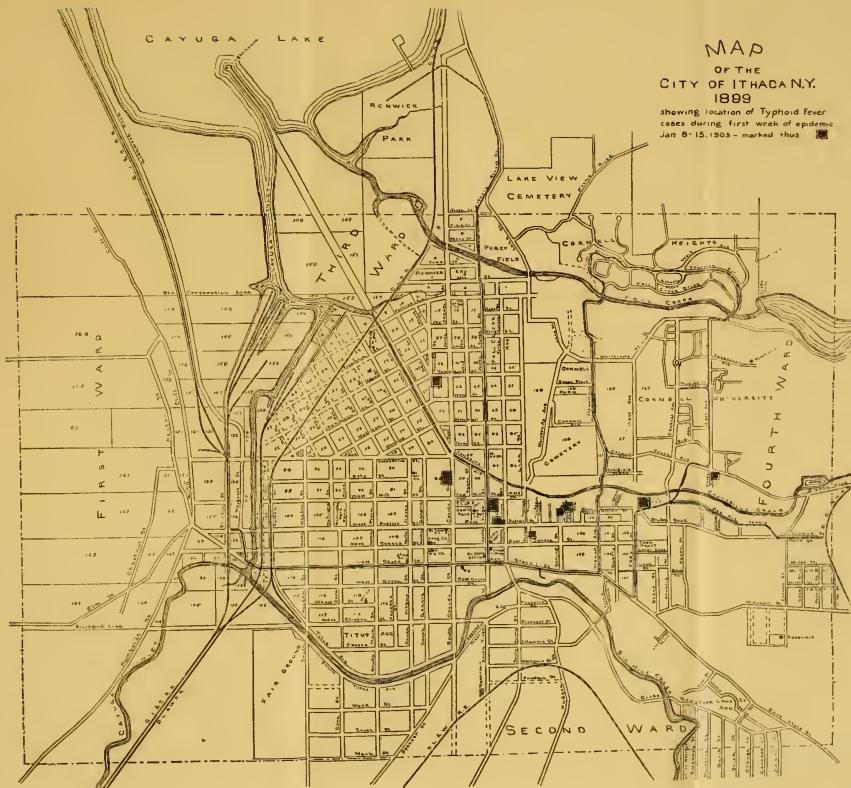
One in every ten was taken with the fever, and one in every hundred died of it. It is probable that more typhoid occurred in the section occupied by the students than in other sections of the city because of the peculiar susceptibility of young people to typhoid and also on account of the fact that some of the students lived amid surroundings which were insanitary.

The epidemic is officially regarded to have begun on the 11th of January, 1903, and to have extended to the 1st of April of the same year. But in reality there were some cases before the date given, and there were many after it. Plate I is a map of the city showing the location of the typhoid cases during the first week of the epidemic.

What might be termed a long, low wave of typhoid appears to have set in about September, 1902, and continued until about January, 1904. In this whole period it appears that typhoid fever was somewhat unduly prevalent. It is impossible to state the facts. Under the most favorable circumstances nothing is more difficult than to obtain an accurate knowledge of the extent to which typhoid occurs in a community. Records of cases of typhoid fever were never accurately collected at Ithaca, and were gathered with difficulty during the epidemic. The official figures collected for the State Department of Health were made up with great care, but they are known to be defective. The total number of cases given above, which is the official figure of the State Department, was estimated from a large amount of data collected in various ways, and does not represent the number of cases actually reported by the physicians. The number so reported was much smaller.

MAP OF THE CITY OF ITHACA, N.Y. 1899

showing location of Typhoid fever
cases during first week of epidemic
Jan 8-15, 1903 - marked thus 



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TABLE NO. 1.

Showing the number of cases of typhoid fever reported by the physicians of Ithaca, N. Y., from January 10 to April 1, 1903. (The actual number of cases was much greater and they were somewhat more regularly distributed.)

Date.	Typhoid Cases Reported.	Total Cases Reported for Week.	Date.	Typhoid Cases Reported.	Total Cases Reported for Week.	Date.	Typhoid Cases Reported.	Total Cases Reported for Week.	Date.	Typhoid Cases Reported.	Total Cases Reported for Week.
Jan. 10	0		Jan. 30	14		Feb. 19	13		March 11	3	
11	1		31	22—105		20	18		12	0	
12	3		Feb. 1	30		21	11—102		13	2	
13	1		2	37		22	19		14	1—18	
14	4		3	26		23	11		15	2	
15	5		4	19		24	5		16	0	
16	3		5	17		25	7		17	0	
17	4—21		6	19		26	7		18	1	
18	5		7	22—170		27	4		19	0	
19	6		8	26		28	6—59		20	0	
20	6		9	21		March 1	18		21	0—3	
21	6		10	19		2	3		22	0	
22	12		11	17		3	2		23	0	
23	10		12	21		4	1		24	1	
24	9—54		13	15		5	4		25	1	
25	11		14	18—137		6	2		26	0	
26	14		15	19		7	1—31		27	1	
27	13		16	12		8	2		28	0—3	
28	16		17	13		9	5		29	0	
29	15		18	16		10	5		31	0—703	

Total cases reported, Jan. 10 — March 31, inclusive, 703.

The total number of typhoid fever cases which were directly or indirectly attributable to the outbreak at Ithaca will never be known, and cannot safely be estimated. If to the number which occurred in the epidemic, there were added those which occurred before and after it, and the cases which broke out in other places to which infection was carried by those who fled from the city, the total would be considerably increased.

ORIGINAL SOURCE OF THE EPIDEMIC.

In seeking to determine the cause of the epidemic, inquiry was directed to every conceivable quarter. As the infection was general, a common cause was naturally suspected. The city was not in an entirely sanitary condition, and it was appreciated that while certain features existed which were favorable to health,

there were others which favored the spread of the fever. Among the features favorable to health may be mentioned an excellent climate, and an abundance of high ground. The unfavorable features included an incomplete sewerage system; a high ground water level in a large part of the city; an inadequate and polluted water supply; the presence of innumerable shallow wells; and an unusual prevalence of private cesspools and privies.

There is no room to doubt at the present time that the water supply was the original source of the disease, and that the fever spread through the city the more readily and became more securely established because of the insanitary conditions referred to, and carelessness and ignorance in nursing the sick.

The water supply, or supplies, of Ithaca were derived from three separate sources. Two of these sources were in the control of the Ithaca Water Company, while the third source was in the control of Cornell University. It has been claimed by the university authorities that no fever occurred among the people who used exclusively the university's water supply. This is true. The university's water was polluted, but was not infected, so far as I could find out. It was supplied exclusively to the campus. It seems certain that the infectious matter came to the city through one or both of the supplies of the water company.

The two water supplies of the water company are derived from creeks. The larger source, Six-Mile Creek, drains an area of country of about forty-six square miles. The run-off after storms is rapid, and the stream is subject to sudden and very decided fluctuations in volume. The dry weather flow is about one million gallons per twenty-four hours; the largest quantity of water that has been observed to flow in the creek was about three thousand times this volume. In short, Six-Mile Creek is a torrential stream, deeply eroded through soil and rock and carrying an immense amount of suspended matter, such as silt and sand, after rains and thaws.

On the drainage area of Six-Mile Creek there was a population estimated by the census of 1900 as 2 144, of whom 812 lived in villages bordering the creek. The nearest village, called Brookton, is five miles above the intake of the water works. No care



FIG. 1. — General View of Ithaca, showing Cornell University on the hill, student quarter on the right, and valley of Six-Mile Creek on extreme right.



FIG. 2. — Map showing drainage areas of creeks near Ithaca.

whatever had been exercised for years to prevent drainage from entering the stream, although at one time, under different management, the protection of the drainage area is said to have been very carefully looked after. At the time of the epidemic numerous sources of pollution were evident. Representatives of the water company who were sent out at my request to inspect the drainage area brought in records of over one hundred nuisances. Within the very city of Ithaca, and but a few rods above the intake of the water works, there were located on the precipitous banks of Six-Mile Creek or its tributaries no less than seventeen privies.

There was no system of purifying the water, unless a primitive filter crib could be so called. The crib was located on a bank of the stream and was principally useful in excluding pebbles and leaves from the pumps. A small impounding reservoir had been formed by throwing a dam across the stream a short distance below the intake crib. Besides the intake crib, there were two other intakes; one above the impounding reservoir, and one below it. These were but little used, and all took the same water.

The water was pumped from the creek into a standpipe of small capacity, and flowed thence through the mains to the consumers.

A second source of supply of the water company was Butter-milk Creek, draining about twelve square miles of country. Here were duplicated, but on a smaller scale, the sanitary conditions of Six-Mile Creek. Most of the water which supplied the city came from Six-Mile Creek, but a general and uncertain mixture of the two took place in the pipes.

From what has just been said it will be apparent that the conditions were ideal for an epidemic. During periods of dry weather quantities of refuse of all descriptions accumulated on the banks of the creeks and their tributaries, to be scoured down into the water supply by the next rain or thaw.

In a very careful survey of the drainagé areas which I made during the course of the epidemic, I was able to locate six cases of typhoid fever which had occurred in the twelve months preceding the outbreak at Ithaca. It is possible that other sources of infectious matter existed. For example, there was one hotel

on the upper waters of Six-Mile Creek which was frequented by people in search of health, and it is not impossible that some persons recovering from typhoid spent the summer or autumn there. Such people are as dangerous as those actually confined to their beds with typhoid, for in about twenty per cent. of all cases the germs of typhoid become established in the bladder and are given off in great numbers with the urine for weeks and sometimes months after apparent recovery.

If there was dangerous filth on the banks of the streams supplying Ithaca with drinking water, the weather conditions just previous to the outbreak of the epidemic were such as to wash this material into the creeks. The report for December, 1902, of the New York Section of the Climate and Crop Service of the United States Weather Bureau, says that December was noted for exceptionally heavy precipitation, the fall of snow and rain at Ithaca being more than twice as much as for any other December since the establishment of the station in 1879. General rains and thawing conditions prevailed from the nineteenth to the twenty-second, with very heavy falls on the thirteenth, sixteenth, and twenty-first.

If we assume that infectious material was scoured from the banks of the streams during these rains and thaws we must account for the fact that three or four weeks seem to have elapsed from the time when it was taken into the water works system to the beginning of the epidemic in the city. Theoretically, it would take only two or three days for the water to get from the creek to the consumer by way of the force mains, standpipe and distribution system, and we should expect the first cases of fever to develop within two weeks from this time. The actual time which elapsed was nineteen days; the outbreak was not in full force for several days after. The apparent delay in the appearance of the epidemic is probably due to the fact that the dates of the commencement of the attacks are in reality the dates when the physicians were first called; several days may have elapsed between the appearance of the first symptoms and the calling of medical aid.

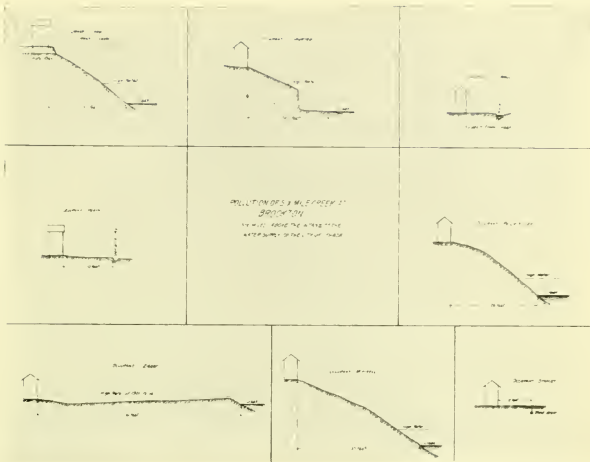


FIG. 1. — Some sources of pollution of Six-Mile Creek at Brookton.



FIG. 2. — Some sources of pollution of Six-Mile Creek at Brookton.

OTHER THEORIES OF THE CAUSE.

Before leaving our discussion of the cause of the epidemic it may be well to take account of a belief which was held by many that the outbreak was not due to pollution of the streams by permanent residents on the drainage areas but was caused by the offscourings of a gang of Italian laborers who were at work on the construction of a dam on Six-Mile Creek, a short distance above the water company's intake.

Careful investigation of the grounds of this theory was made without discovering, however, that excrement from this source had entered the stream, or that any of the laborers had been ill. It is, of course, conceivable that one or more of the laborers had recently recovered from typhoid and that their infected urine entered the creek, but the chance of such contamination seems remote.

The work was in charge of professional engineers of high standing, and precautions were apparently taken to prevent any polluting matter from entering the stream. A young man who had recently graduated in engineering at Cornell was especially detailed to look after this matter. There is little doubt that bad feeling between the citizens and the water company, caused by a dispute over the construction of a new dam, accounted in some measure for the mental attitude of some citizens on this point.

Another possible source of typhoid material existed on one of the tributaries of Six-Mile Creek within three miles of the water works intake. At this point a gang of laborers of mixed nationality but common bad character had been engaged in building an elaborate railroad culvert, through the late summer and early fall months. One "Toothless Ben," a member of this party, was taken with typhoid fever while on the work and was eventually compelled to leave it and go home to be nursed. I found ample evidence that these men had defecated on the banks of the stream, but whether infectious matter from "Toothless Ben" had been deposited here and had later been washed down into the water supply of Ithaca it was not possible to determine.

Finally, an irregularity in the operation of the pumps of the

water company remains to be mentioned as having a possible bearing on the cause of the epidemic. Owing to the expected need of an unusually large supply of water for some tests of fire apparatus, an extra, and generally idle, pump was set in operation for several days preceding December 25. The intake of this pump was in a penstock directly connected with Six-Mile Creek. The water was neither purified nor screened, but was forced directly to the standpipe which was, at the same time, being supplied by the regular pumps.

Whatever theory is accepted to account for the infection of the water, it seems necessary to conclude either that the germs multiplied after entering the distribution system, or that they were taken in during a period of several weeks. It is scarcely conceivable that a sufficient number could have been taken from the creeks at one time to last as long as the water remained infected. It is equally improbable that the germs multiplied in the pipes. It seems necessary to conclude that the impounding reservoir remained infected for several weeks. The whole water works system should have emptied itself in less time than one week.

The onset of the epidemic was very gradual. The first case required the services of a physician on January 11. Two new cases were seen on the next day. On the day following there was but one case. On January 14 there were four; on the 15th, five; on the 16th, three. Presently, the daily number of new cases largely increased. On the 22d there were twelve; on the 28th, sixteen; on January 31, twenty-two; on February 2, thirty-six. Thereafter the number decreased and increased alternately with a general declining tendency.

PREVIOUS HISTORY OF TYPHOID AT ITHACA.

In considering an outbreak of typhoid it is instructive to inquire whether the disease is new to the place or has existed previously. The value of such evidence depends upon its accuracy. Unfortunately the records of cases and deaths from the infectious diseases are not kept with sufficient accuracy even in our best regulated cities to enable a correct idea to be formed of the amount of typhoid which has been present.



FIG. 1. — Privy and Ditch at Brookton on Six-Mile Creek; said to have received typhoid dejections.



FIG. 2. — Six-Mile Creek between Slaterville and Brookton.

Previous to the epidemic, no records whatever had been made of the cases of typhoid fever which had occurred in the city at large. The best information that can be gained on this point is contained in the records of the principal hospital. These records show the comparative amount of typhoid which occurred from year to year.

Were the death records accurate, some idea could be gained from them of this relation. The following letter, however, from one professor of Cornell to another shows the incompleteness of even this generally accepted source of information:

ITHACA, N. Y., March 12, 1903.

Dear Dr. T—, The death rate of Ithaca is something almost impossible to ascertain, owing to omissions in the record. Several years ago I had three students working on the subject for months and we reached the conclusion that the omissions from the record were 29.4 per cent. in one year, and 33 per cent. in another. On the basis of the corrected figures they established for 1892 and 1893, the true death rate was 16.5 instead of 13.4, which was claimed. Recent official figures are doubtless more accurate, owing to the changes made in the registration law about 1895.

That the records, however, are still incomplete is shown by the Twelfth Census. The registration record of the city for the census year from June 1, 1899, to May 31, 1900, shows 196 deaths; the census enumerator's return, obtained by asking at each house in town whether any death had occurred in that family during the preceding twelve months, showed 100 deaths. Successive comparisons of these two lists, name by name, showed in the latter 17 names not in the former, giving a total of 213 deaths in the city for that year, as accepted by the Census Office, or a death rate for 1900 of 16.3.

Yours sincerely,

— — —.

A report from Dr. F. C. Curtis to Dr. Daniel Lewis, State Commissioner of Health, gives the opinion of the medical expert of the State Department of Health on the previous history of typhoid at Ithaca. The report is dated Albany, February 7, 1903:

Sir,—The records show that for the past two or three years Ithaca has had an autumnal prevalence of typhoid fever. In 1900 and 1901, the mortality rate from this cause was about 40 per 100 000 population; and in 1902, however, there was but a single death.

The following table has been made out from data taken from the books of the Ithaca City Hospital:

TABLE NO. 2.

Cases of typhoid fever and similar diseases treated at the Ithaca City Hospital from 1892 to 1902 inclusive.

	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Totals
Jan.	0	0	1	0	0	0	0	0	1	0	1	3
Feb.	0	0	1	0	1	0	0	0	2	2	3	9
March	0	0	0	1	1	0	0	3	0	1	2	8
April	0	0	0	0	0	0	0	0	0	1	4	5
May	1	0	0	1	0	0	0	0	1	0	4	7
June	0	2	1	0	0	1	0	0	0	0	0	4
July	5	0	0	0	0	2	1	0	0	0	0	8
Aug.	3	0	0	2	6	2	3	0	0	7	2	25
Sept.	10	3	3	2	4	9	1	0	7	10	3	52
Oct.	3	3	4	1	2	1	1	1	4	10	2	32
Nov.	0	2	3	0	1	0	1	1	9	3	0	20
Dec.	2	1	0	0	0	0	0	0	3	2	2	10
Totals	24	11	13	7	15	15	7	5	27	36	23	183

PUBLIC ALARM FOLLOWING THE OUTBREAK.

The outbreak of the epidemic caused a great deal of concern among the people who lived at Ithaca or who had sons at the university. It soon became known that the City Hospital was full to overflowing and that the Cornell Infirmary, where sick students were always treated, was becoming overcrowded. The hospital called for public aid to help meet the extraordinary expenses incurred in caring for so many of the sick, and subscriptions were opened to give similar help to the infirmary, where the students were being treated.

The local board of health, with the aid of its health officer, Prof. E. Hitchcock, Jr., and Profs. E. M. Chamot and V. A. Moore of Cornell, made some investigations as to the cause of the epidemic which disclosed the unsanitary conditions on the drainage areas from which the water was obtained, and pointed to the public water supply of the Ithaca Water Company as the probable source of the infection. The board promptly ordered that the city water be boiled before being used for drinking purposes.

It is important to state that Professors Moore and Chamot, in reports previously made to the local board of health, had warned that body that the water supply was polluted; and that the results of their analyses had been suppressed and kept from



FIG. 1. — Outlet of drain from Acetylene Plant at Slaterville Springs on Six-Mile Creek.



FIG. 2. — Six-Mile Creek at Slaterville.

the public press by the board for fear of alarming the people. These and other disclosures of real or imaginary delinquencies on the part of the local board of health, water company, and trustees of Cornell University gave the friends and foes of the university and city abundant food for criticism. The result was that more time was spent in trying to fix the blame for the epidemic than in bringing it to an end.

By this time the city was in a condition bordering on panic. New cases of fever were appearing at the rate of twenty or more a day and the epidemic was gaining headway rapidly. Hundreds of students were leaving the university, notwithstanding strenuous efforts to keep them in the city. The railroads brought no one to Ithaca but carried heavy loads away. Business was at a standstill. The public press throughout the country, making capital of the epidemic, gave the widest possible advertisement of the unfortunate situation.

When the number of cases had reached several hundred the State Department of Health sent a representative to Ithaca in the person of its expert on infectious diseases, Dr. F. C. Curtis. Dr. Curtis spent a day at Ithaca investigating the conditions, and a few days later forwarded a report stating that undoubtedly the disease was typhoid fever and that the water supply of the water company was to blame for the epidemic; the source of the infection was probably a gang of Italian laborers. He advised the people to boil the water, and prophesied that in a short time the epidemic would wear itself out.

But matters grew steadily worse and the Commissioner of Health of the State, Dr. Daniel Lewis, went to Ithaca to investigate personally. Consultations were held, public addresses were made and various measures of relief were recommended. Foremost among the instructions given by Dr. Lewis to the local board of health was to insist on thorough disinfection. This should include not only the disinfection of the stools, but also of the urine of the typhoid fever patients. It was desirable that household disinfection should be practiced also; and to insure that this should be properly done the commissioner recommended that competent medical inspectors be employed. Fi-

nally, but of the utmost importance, the local board of health was urged to compel physicians to report their cases of typhoid fever under the penalty of being fined from twenty-five to fifty dollars for each offence.

But the people of Ithaca were beyond advice. Internal dissensions, and the utter demoralization of the commercial and educational interests of the city, not to speak of the spirit of apprehension which pervaded every household, made it impossible for them to unite on any form of local leadership to initiate the measures which were necessary to restore public confidence and put an end to the epidemic.

It was under these circumstances that I was requested by the State Department of Health to go to Ithaca and see if I could bring about relief. I arrived at Ithaca on March 4. Thanks to the energetic coöperation which I at once received from the officials and employees of the city government, the authorities and professors of Cornell University, the president and others of the Ithaca Water Company, and the citizens themselves, the difficulties of the situation cleared rapidly. Public health work of a kind seldom seen outside of military situations soon regained for the board its lost prestige. Public confidence was gradually restored. The authorities of Cornell, from being on the point of closing the university, decided to keep it open and to hold a summer session. The frightened students returned; business was re-established. By the 1st of April I notified the local board of health that I saw no further need of my services, and that I should return to New York, leaving the sanitary work in their hands. I was requested to remain and supervise the work of the board until September 1, 1903, taking up, at the same time, the study of means for improving the drainage of the city. Satisfactory arrangements were made for this work and I remained.

Throughout my residence at Ithaca my official position was that of representative at Ithaca of the New York State Department of Health. In this capacity I acted as expert advisor to the local board of health. The steps taken to extinguish the fever were carried out by the local board, acting, as a rule, upon suggestions from me.

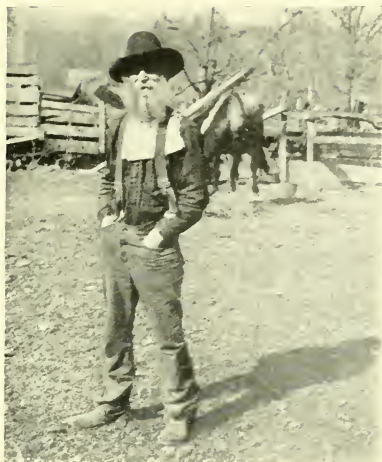


FIG. 1. — "Dirty Baker."



FIG. 2. — Home of "Dirty Baker," Buttermilk Creek drainage area.

THE SANITARY CAMPAIGN.

At the outset it was recognized that there must be money available for the sanitary work. The nature and extent of the preventive and corrective measures which were thought necessary were explained to the board of aldermen, who thereupon pledged to the board of health the credit of the city.

The first thing to be done was to determine the origin and extent of the epidemic. An investigation was begun to discover as nearly as practicable where each case of fever originated, and when and where it occurred. Statistical records were made embodying this and various other pieces of information connected with the identification and location of the fever victims. The work was carried on with extreme care, several men being engaged upon the records for many weeks.

In order to bring about harmony of action, numerous conferences with representatives of the principal interests at Ithaca were held. Some of these were of a public, and others of a private, nature. At a meeting of the board of health, at which representatives of the city government, of the water company, and of the university were present, all pledged themselves to harmonious action. At a meeting of the physicians of the city, various technical matters and many opinions concerning the epidemic were discussed. Public conferences in the form of lectures were held, at which the principles of disinfection and household sanitation were dealt with. In articles offered to the press, instructions were given in the use of various protective measures against the fever, and the sanitary ordinances of the city which had a bearing on the situation were dwelt upon.

It was found early that the disinfectants employed by the nurses were not of reliable quality, and, as good disinfectants were difficult to obtain, the city was advised to prepare and supply these necessities. The disinfectants chosen for distribution by the city were milk of lime and bichloride of mercury. These were supplied wherever a case of fever existed, four wagons being employed to make the rounds. The total quantity of milk of lime distributed was 23 231 gallons. The quantity of bichloride of mercury was 1 930 gallons.

An investigation was set on foot to determine the cause of the epidemic, and various important matters connected with this topic were soon discovered. There was no doubt that the drinking water supplied by the water company was the original cause of the epidemic, but it was evident that the disease was being transmitted from person to person through carelessness and ignorance in nursing the sick. The sanitary condition of the city, which had been somewhat improved within eight or ten years, was in need of improvement.

There were two obvious sources of danger in this direction. The city contained about 1 300 wells and nearly an equal number of privies. The latter were constructed without reference to seepage, unless a desire to have the liquid wastes escape into the ground might be so interpreted. It was thought advisable to clean and disinfect the privies and to analyze the waters of the wells. This work was undertaken in April and concluded in August.

The total volume of excrement removed was 418 193 gallons. The material excavated from the privies was taken into the country and plowed into the soil. Twelve acres of poor ground were used for the purpose. Later, a remarkably successful crop of corn was grown upon this ground. It is a satisfaction to be able to say that in this extensive and dangerous piece of scavenging work there was no sickness nor accident among the fifteen employees and eight horses continuously engaged.

As a result of the analyses of well waters, over 30 per cent. of the wells were condemned. The total number of waters analyzed was 946. It is interesting to note that whole portions of the city could be blocked out by the records of the well examinations. In some sections, the water of nearly every well was polluted, while in other sections the wells could all be depended upon as good. The good wells were in clay; the poor ones in fissured rock.

In order to determine the character of many suspected cases of fever, a large number of Widal examinations of blood were made. These proved of great value.

To make certain that the milk supplies did not become infected, careful inspections were made of all the dairies furnishing the



FIG. 1. — On the flats of Ithaca; flood due to high water in Cayuga Lake.



FIG. 2. — On the low lands of Ithaca.

citizens with milk. Other food supplies were examined into, and the quality and care of these important necessities were much improved.

The work on the statistics of the epidemic soon showed that a disproportionately large number of the students of Cornell University had been attacked by fever, and, in consequence of this fact, inspections of boarding and rooming houses occupied by the students were systematically made. Every point of sanitary importance connected with the living quarters of the students was carefully examined and recorded, as a result of which each house was given a sanitary rating. A list was published containing the address of every boarding house which passed the examination.

One of the most important measures adopted, and, it is thought, an innovation in the management of typhoid epidemics, was the use of urinary germicides to eliminate bacterial infection from the bladders of convalescents. As is well known, the bladder, in a large number of cases of typhoid fever, becomes infected and enormous numbers of the disease germs are given off in the urine. Analyses of urine were made to determine the existence of the *bacillus typhosus*. In the event of the discovery of this germ the patient was held under observation and given urotropin until the bacillus disappeared.

It was not long after the introduction of systematic measures for the suppression of the epidemic that public confidence began to be restored. The number of new cases of fever reported from day to day rapidly diminished, and although an occasional case appeared for several months, the epidemic ceased by April 1.

THE LESSON OF THE BARNES WELL.

It is proper to refer, before closing this account of the Ithaca epidemic, to an outbreak of fever which took place in one section of the city after most of the other cases had disappeared. This outbreak was the result of the contamination of a well on the property of a man named Barnes. The Barnes well had been famous; people who had learned to fear the city water went to the Barnes well with a feeling of perfect safety.

No one had ever been made sick from drinking this water. So great was the demand upon the well that the water was actually piped to another house.

It was the original intention of the local board of health to examine every well in the city, and had this plan been carried out, the Barnes well would have been found to be polluted in time to prevent the outbreak which followed. Unfortunately, in a moment of economy, the well examinations were stopped and the Barnes well was one of a very few not tested.

In about two weeks after the board of health stopped analyzing the well waters, many of the people who had been drinking from the Barnes well were taken ill. In all there were fifty cases of typhoid and five deaths traced to this well.

When suspicion was directed to the well, I visited it and had the drain pipe from the water closet in the Barnes house excavated. The drain ran within three or four feet of the well. When the laborers dug the earth from beneath the drain, they found that the joints had been scamped; that is, insecurely and improperly closed. When the water closet in the Barnes house was flushed, the water would run through the drain to a point about ten feet from the well, whence it would flow out into the porous soil through the leaky joint and so into the well. On analysis, the water of the well was found to be grossly polluted.

We needed, however, to find out how the drainage which entered the well had actually infected it. It was then discovered that Mrs. Barnes had suffered, some weeks before, with a mild attack of typhoid fever, which had been pronounced by her physician to be grippe. We proved the real character of her disease by taking a specimen of her blood and examining it in the laboratory. The dejecta from this patient passed down through the water closet without disinfection; it escaped from the drain pipe into the well and, as we have said, occasioned fifty cases and five deaths.

INDEPENDENT SANITARY MEASURES.

I have not mentioned all of the sanitary measures which were taken to suppress the epidemic of typhoid and guard against future difficulty, but have indicated some of the most important,



FIG. 1. — Conditions which added to the difficulty of sanitation on the low lands of Ithaca.



FIG. 2. — Celery and other vegetables growing in a back yard at Ithaca.

with the idea of furnishing examples of the work done by the local board of health, under my advice. Important things were done by the city, the water company, and the university, sometimes without formal coöperation with the health authorities. The water company constructed a municipal filter plant at a cost of something like seventy thousand dollars. The plant was designed by Mr. Allen Hazen and built under the supervision of Prof. Gardner S. Williams. This filter is now in operation, purifying the water of Six-Mile Creek, on the rapid or mechanical filter principle.

The water mains of the distribution system were flushed, the city being divided into sections for this purpose, and the whole work was carried on under the direction of Professor Williams.

Rules were made and established legally for conserving the purity of the water of Six-Mile Creek and Buttermilk Creek. These rules included precautions to be taken in the construction and maintenance of privies, the disposal of sewage, stable wastes, etc., and forbade washing and bathing in the streams.

The citizens undertook to find a new source of water supply which could not be contaminated, and sunk many wells in this undertaking. It is reported that their efforts have at last proved successful and that there is now an abundance of water available from the wells.

New methods of cleaning the streets and disposing of garbage and other refuse were inaugurated. A cremation plant for the consumption of refuse was erected to meet the emergency of the epidemic. Although this plant was for temporary use only, it is said to be in operation still.

A thorough municipal house-cleaning was instituted early in the spring. House-holders were induced to open up their hermetically closed dwellings to the free air and clean them out from attic to cellar. Back yards, forgotten alleys, and other unsightly places were cleaned up. The amount of rubbish brought to light was astonishing.

The sanitary code of the city was enforced in a manner previously unknown. Emphasis was placed upon the necessity of boiling the city water before using it, but, strange as it may seem,

this precautionary measure was continually evaded. To further prevent the people from drinking this dangerous supply, water from a pure, free-flowing well was peddled from house to house at the nominal price of one cent per gallon.

COST OF THE WORK.

The total cost of the sanitary campaign was somewhat over \$108 000. This takes into account the cost of the filtration plant built by the water company. The board of health itself spent \$10 000. The privy cleaning cost \$5 000 more; the inspection and plumbing improvements of students' boarding houses are estimated to have cost about \$10 000 additional; the construction of the garbage destructor and improved collecting service cost \$3 000. Filters, which I have not before mentioned, constructed for the purification of the water supply of Cornell University, cost about \$10 000.

PRESENT OUTLOOK WITH RESPECT TO TYPHOID.

The history of typhoid at Ithaca from the end of the epidemic to the present time may be of interest. I have just been informed by the health officer that in the year ending September 1, 1904, there were in the whole city thirty-six cases of typhoid fever. Of these, twenty-eight occurred before the first of January and the remainder since. Those which took place from September to January are regarded by the board of health of Ithaca as due to the drinking of water from mains which had not been thoroughly cleaned.

It is doubtful if typhoid fever will ever gain a foothold in the city again. The work of extinguishing it was thorough and apparently complete. The record for the year following the epidemic is probably cleaner than any record would have been for many years, had the returns of cases been as accurately made. The site of the city is one of great beauty and natural attractiveness. It can, and probably will, be made one of the healthiest and best regulated cities in the world. If this is done, its destiny is clear. So long as the great university remains, Ithaca will be a city of homes, and the people will be intelligent and



FIG. 1. — Sewer manhole overflowing, during exceptionally high stage of Cayuga Lake.



FIG. 2. — Method of disposing of excrement removed from privies after the epidemic.

cultivated. They should now be far-seeing in sanitary matters. Seldom has so terrible a lesson of the consequences of sanitary neglect been given. That the world believes that this lesson has been well learned is evident by the fact that the prosperity of the city suffered no permanent impairment. The freshman class which entered Cornell in the autumn following the epidemic was the largest in the history of the university.

DISCUSSION.

MR. FRANK L. FULLER.* We have all been very deeply interested in what Mr. Soper has said, and I think we are greatly indebted to him. Those of us who have to do with water supplies ought to receive a new impulse to see to it that our supplies are carefully guarded from sources of pollution. It seems to me that this is the most vivid illustration of carelessness and poor management that we could have had brought before us.

There is one question I should like to ask Mr. Soper. He spoke about the cleaning of the water pipes during the latter part of the time of the epidemic, and I should like to ask what method was pursued in doing it.

DR. SOPER. The question was thoroughly considered, and it was proposed by Prof. L. M. Dennis of the Department of Chemistry of Cornell that the pipes should be disinfected. He wanted to send to Europe, I think, for a large quantity of permanganate of potash, and run it into the distribution system in some way and so destroy all the infectious germs. Professor Dennis thought this would not do any injury to the pipes or to the connections. It was finally decided, however, that it might not prove as effective as hoped, and that it might have this effect: If the pipes were not thoroughly disinfected a calamity might result, as the people would in all probability give up boiling the water if they thought the germs in the pipes had all been destroyed. Other methods of disinfecting the pipes were considered, and after a conference with representatives of the water company, and particularly with Prof. Gardner S. Williams, who was the engineer of the water company, it was thought best to flush out the mains as thoroughly as feasible, as

* Civil Engineer, Boston, Mass.

soon as the improved water supply was available, — that is, as soon as the filters were put in operation; and that was done by dividing the city into sections, and concentrating the pressure first in one quarter and then in another. I should not like to say that I considered that sufficient. I do not believe that Professor Williams did, and I do not believe any one would, but it seemed to be the best thing that was available at that time.

A MEMBER. What was the condition of the inside of the pipes? Were they smooth, showing the treatment which the pipes were originally subjected to, or were they covered with tubercles and was sediment deposited, or were they clean and bright?

DR. SOPER. I think there were many portions of them which were tuberculated, and there was considerable sediment, I think, in some of them.

MR. KENNETH ALLEN.* I think perhaps this is the most thorough investigation which has ever been made of a public water supply, and I think one of the interesting features of the investigation is the number of different points of attack that were developed, the many different sources of infection that were brought out. I would like to ask Dr. Soper if it was supposed that there was much infection through dust containing typhoid germs being blown about?

DR. SOPER. It did not seem to be so. You see it was so early in the season that there was little dust excepting in houses, but it was thought that dust might have played quite an important part in the houses.

MR. ALLEN. You spoke of the danger of infection from pig-pens and manure heaps. The original source, of course, would have to come from a typhoid fever patient, would it not?

DR. SOPER. The danger I referred to was this: In the epidemics I have investigated, I have invariably found that the male population of the farm uses the manure pile as a receptacle for their excrement. The women use the privy, and the men go out to the barn. Now, if a man has typhoid germs in his intestines and in his bladder and is throwing them off, he will throw them off into the manure pile.

MR. ALLEN. That is a very interesting point. Is it known

* Engineer and Superintendent, Water Department, Atlantic City, N. J.

or is there a preponderance of opinion one way or the other, as to the identity of the form of the typhoid bacillus?

DR. SOPER. That is, perhaps, one of the most vexed problems now before bacteriologists. One of the latest ideas I am almost afraid to speak about because it seems to tend to upset past theories which have been very carefully built up. But there is a young man who has made some observations in Strasburg who claims that the ordinary colon bacillus may, under some circumstances, be transmuted or transformed into the typhoid germ. But I think it is the prevailing opinion among conservative bacteriologists that we should regard that theory with doubt until the matter is more carefully investigated.

MR. ALLEN. I happened to be at Ithaca when Dr. Soper was making these investigations, and I can testify to the feeling of panic there was among the people there, especially the students.

MR. E. H. FOSTER. I should like to ask Professor Soper how near to the intake of the water company the first positively known source of pollution was, and how near it the culvert was where "Toothless Ben" was working.

DR. SOPER. I can answer the second question more briefly than the first. The culvert where "Toothless Ben" worked was within three miles of the intake, measured by the stream. The nearest source of pollution was, I should say, an eighth of a mile, and that was one which a superficial investigation might have hit upon as the cause of the epidemic. It was the residence of a woman of notorious character. Just prior to the epidemic she had been suffering from a disease which she herself pronounced unmistakably typhoid fever. Her physician did not call it that. He said she suffered from grippe. With a good deal of difficulty I got some specimens of her blood, and they did not give the positive result of typhoid. That, however, did not prove that the woman had not had it. There is no doubt that the waste from the house was thrown down the precipitous bank of the stream within an eighth of a mile of the intake of the water supply. It may be that this was the cause of the epidemic. I must say, however, that I have not in my own mind fixed upon the pollution of the water supply at any one specific point as the sole and sufficient cause of the Ithaca epidemic. Among such a large number

of sources of pollution as were obvious, it was difficult to discriminate. Any one of over a dozen might have been the cause.

MR. L. M. HASTINGS.* I suppose that what we have heard here to-day brings to the mind of every superintendent the possibility of the pollution of his own supply. When we have heard how great a result may come from a slight cause, it certainly is a matter for the gravest consideration and something to incite us to the closest examination of our water supplies. I remember a few years ago Professor Sedgwick spoke of the epidemic at Lowell, and he traced that, I think, to one solitary case of typhoid on a stream some miles from the city. Now, if that is the case, what protection have we against an epidemic from a cause which it is impossible to detect? If a single case of typhoid on a remote branch of the system may affect the whole system, it does seem as though our health and lives were in a pretty precarious situation.

There are some precautions which I suppose we can take to reduce the likelihood of infection. I suppose the first thing would be to make a sanitary survey of the whole watershed and locate the most dangerous points. That is most commonly done nowadays by a house-to-house visitation and abolishing as far as possible the points of contagion. In some cases where privies have existed before the taking of the water supply, it would seem as though the only thing to be done was to introduce some improvement, and I know that on the Cambridge supply where such danger has existed, the water board at its expense has abolished privies and open cesspools and substituted water-tight brick vaults. Those brick vaults are cleaned out by the water board. This is a precautionary measure against just such cases as Dr. Soper has referred to this morning. I don't know whether any method of disinfection by copperas or other chemicals would be sufficient, but it does seem to me that where such sources of pollution exist on the water supply or its branches, something of this sort would be efficient.

There is one matter the doctor spoke of which interested me. He said that young men are more subject to typhoid infection than old men are. I suppose in a generic way that that is true,

* City Engineer, Cambridge, Mass.

that all young men are more subject to fevers and older men are more subject to inflammations. I should like to ask the doctor if he knows of any reason why young men should take the typhoid fever more easily than old men.

DR. SOPER. No, I do not know of any reason. Of course, it is not young men only, but young women also. If you examine any exhaustive work on hygiene you will find tables showing the relative prevalence of typhoid among people of all ages. It seems that there is an age relation with many of the infectious diseases. Measles and other diseases that we commonly speak of as diseases of childhood attack young people more than old people, not because old people have had the diseases once and so are immune to them, but apparently for some other reason, children are more susceptible.

MR. EDWARD ATKINSON. I remember there was a serious epidemic at Windsor, Vt., a few years since. Desmond Fitzgerald was sent for in haste, and he went up there and found a single case of typhoid in a farmer's house which drained into the water supply, and from that single case the water supply of Windsor, which is one of the most healthy places in the country, had been infected and an epidemic had resulted.

PROF. E. G. SMITH.* I want to express my appreciation of what Dr. Soper has said this morning and of the very thorough way in which he has gone into the unearthing of the mysteries of the epidemic at Ithaca. Those of us who have had to do with this sort of a problem elsewhere realize very keenly the labor involved and the thoroughness with which the work has been done. I was much interested in the discussion of the cases, and I raised in my own mind the question of how many of them were due really to the water, and how many, or what proportion, of those 1 350 cases were due to what we call "contact infection" or "comrade infection." I don't know as the doctor has any data bearing upon that point, but it is certainly an interesting one. The fact remains, however, that the primary infection of that community was due to the impurity of the water and to the shocking conditions which existed above the intake of the public supply.

* Beloit, Wis.

I wish I had time to say something which would be corroborative, perhaps, of the line of work which has been carried out at Ithaca. There is another chapter there in this old, old story of the pollution of our supplies, our great supplies and our small supplies, by persons suffering from the acute stages of typhoid fever, or, indeed, from those often more dangerous cases of what are known as "walking typhoid." It has been my fortune to examine into some of the epidemics, large and small, which have prevailed in the Western states. I should like to go somewhat into the details of the epidemic at Rockland, Ill., which was directly traceable to the pollution of the water supply. Perhaps later when I may be in Boston, as I hope to be for a few months this winter, I may have the pleasure of speaking to you upon that epidemic, which certainly was a most remarkable one, and the history of which has not as yet, I believe, found its way into print.

I should like to speak of the epidemic at Baraboo, Wis., where we had direct proof that the outbreak was due to contamination of the water supply. It is a comparatively small town, two or three thousand inhabitants only, and there were not more than two hundred cases, with a death rate of perhaps one in thirty, and the evidence was as certain as anything which has been presented here regarding the outbreak at Ithaca. The town is situated on a river. The sewage passes into a canal, which is taken from above a dam below the city, and for some mysterious reason the water supply pipe was laid on the bottom of that canal, the supply being from wells on one side of the canal and the pumps being situated on the other. Why the pipe was ever laid there I cannot imagine, but worse than that, in the pipe was a T and valve so that an extension could be put on, and there were three joints. In consultation with Dr. Russell, of Madison, Wis., I was called on to find the cause of an outbreak of typhoid fever in the town, there being at that time about seventy-five cases. After beating around for three or four days we plotted out the cases as they were reported. We found that they would come in, one, two, three or four, and then suddenly there would be a rise to seven or eight cases; then the number would drop to two or three, and then in the course of twelve or fourteen days there would be another rise. That is, there were waves, as it

were, or periods when there were many more cases reported than at other times.

That led to an investigation as to what had happened on certain dates. Reckoning back to cover the period of incubation of typhoid fever, about fourteen days, we went down to the pumping station and asked them what they did on the date in question. "Did you take any raw river water from the canal that day?" "No, sir; the pumps were operated just exactly on that day as on other days." I asked the engineer, "What did you do on the thirteenth day of July?" reckoning back fourteen days. "We didn't do anything except to operate the pumps just the same that day as before." But somebody went out and came back in a few minutes and said, "Why, that was the day we started the steam pump." Well, on looking up the records we found that the thirteenth day of July was a very hot day, and the water power pumps were inadequate and the auxiliary steam pump had been started. Reckoning back fourteen days the other way we found that on the 27th of July the steam pump had been started again. I turned to the superintendent and said, "You go down and you will find that the packing is out of the joints in that pipe at the bottom of the canal, and that you have got leaks around the joints." Said he, "How do you make that out?" I replied, "I will tell you. Ordinarily the silt will settle down around the joints and the jar of the water pumps is not enough to start it, but the pulsation upon the main pipe when the steam pump was started has been sufficient to jar out the silt." So they drew down the water and found five leaks, one of which you could put your hand through. In other words, the lead had dropped away, the silt had taken its place, and the increased jar on the intake pipe had caused that silt probably to be sucked in and caused a leak, so that the dirty water from this canal could go through and find its way into the main. Fourteen days after that first starting of the steam pump the typhoid fever broke out, and fourteen days from the time the steam pump was started up the second time the fever increased. We ordered that pipe taken out altogether, so that the canal water could not find access at all to the mains, and the epidemic then died out.

I might go over the same story at Ashland, Wis.; I might go over the same story again at Duluth, Minn.; and I might go over the same story again in the city of Minneapolis, where there was a second outbreak this year. And so you will find it is the same story over and over again of the water supply being the primary cause of the outbreak of this dread disease.

A friend back here (Mr. Hastings) asks how we are going to prevent it. The only way is by eternal vigilance. I was called upon to make an investigation of the Denver supply. What did we find? At a point sixteen miles above the lake we found a brother and sister sick in bed with typhoid fever, and the dejecta from those patients were thrown out, without any disinfection whatever, into Bear Creek and found their way to the city. The health commission went up and bought that house and took the sick people — it was in warm weather — out into a tent which was erected temporarily, and burned down the house, cleaned up the débris and covered the spot with loam. To-day if you went out where that house stood you would find a bright, green grass plot.

Eternal vigilance, watching the plant continually and keeping after it, is the only recommendation I have to make to those who have to do with the operating of public water supplies, for it is only in that way that they can be certain of guarding against not only the open causes which everybody knows about, but the far more insidious causes that the public never will know about till the dire result of some great outbreak follows.

MR. M. N. BAKER.* It is certainly appalling to think that such an epidemic, caused by conditions such as have been described, could have occurred so recently; and it is all the more appalling when we realize the fact, as we must, that there are hundreds of other communities that have the danger of the same kind of epidemic, of equal severity, impending at the present moment. As many of you doubtless remember, during the past winter we had a large number of outbreaks, and one or two epidemics which rivaled in importance that at Ithaca. Those outbreaks attracted a great deal of attention, and I think they have

* Associate Editor, *Engineering News*, New York City.

done a great deal to arouse the public mind to the necessity of guarding against them in the future.

The precautions which can be taken against such outbreaks naturally divide themselves under two heads. One of them, and the first, concerns more particularly an association like this, composed of water works superintendents and engineers. The duty of a water works superintendent and of a water board is, of course, to do all that is possible, first to prevent the pollution of the water, and second, to make sure that the water when necessary is purified before it is delivered to the consumer.

Now, in view of the almost insurmountable difficulties in preventing occasional pollution in sparsely populated drainage areas, and the general apathy and indifference of the public, whose interest and support is necessary to prevent contamination, both in the rural districts and in the districts nearer the cities, I think we may say the time has come when we in the United States will have to do as is done in Great Britain and Germany, and begin to make our plans to effectually purify all water derived from surface sources. That subject, of course, might be dealt with at length, but as the time is short, I wish to pass on to the precautions of the other line.

Those are more general in their nature, but as the water works superintendents and other officials have such a great burden of responsibility upon them, I think that they must try to arouse the public, the various municipalities and municipal authorities of the country, to the necessity of a thorough reorganization of the work of the local boards of health. Here is where the trouble arises. Scarcely any of the cities of the United States, to-day, large or small, are taking effective precautions through their local boards of health to protect the purity of their water supplies and to prevent these epidemics of typhoid which arise, not always from water supplies, but from many other sources.

It is for the interest of water works authorities to have the necessary work done to prevent the spread of typhoid through other causes than the public water supplies. Many epidemics, mild outbreaks generally, but sometimes quite considerable ones, come through the milk supplies. The protection of the milk supply is a rural question, and it comes in naturally and is closely

related to the protection of surface water supplies. Now, I venture to say that with efficient board of health work, with sufficient registration of vital statistics, such epidemics as occurred at Ithaca, and more recently at Butler, Pa., and a number of other places, could never have attained the importance that they did. They would have been stamped out long before so much mischief was done; and ordinarily the secondary infection would be prevented by proper board of health work.

There are a few questions which it would be very interesting indeed to discuss at greater length and to have the author of the paper answer, but in view of the lateness of the hour, perhaps the answers to those questions might be given in writing in closing the discussion. There is one thing, however, which vitally concerns us all in view of the educative value of such a study as was made at Ithaca and has been presented in outline here. Why was not that report, which was worked up with great care, and which would have been of inestimable service in carrying on the campaign against the spread of typhoid fever throughout the country, made public? Why has it been suppressed? The report, as I understand it, was completed practically a year ago. The study was made by the Department of Health of the State of New York at great expense, and that report should have been published in a large number of copies and circulated broadcast throughout the state of New York, in order to arouse other communities to the necessity of carrying on preventive work.

Another question is, How could such conditions as existed at Ithaca have arisen in a university town? Now, that is rather a delicate question and opens up an opportunity for a very great deal of discussion. I thought, at the time, a great deal about it, and this thing came to my mind among other things: Philadelphia, for instance, in which is located the University of Pennsylvania, a university city, has been suffering through these many years from a very large number of cases of typhoid fever. The University of Pennsylvania, so far as we know, did comparatively little, but there the problem was so great and so far beyond the influence of the university that we might not expect it could do much except through the individual efforts of some of the members of the staff. I think as a matter of fact that some of them did

have a very great influence in the early days upon the protection of the Schuylkill. But in a smaller place like Ithaca, and like Beloit and many other places where there are universities, the teaching staff of the university can have and should have a very great influence in the protection of the public health. I think that is worthy of reflecting upon, at least. Has Ithaca an efficient board of health to-day? Is it in a position to keep down these dangers along the same line? I have understood that, notwithstanding its severe lesson, politics and a multiplicity of conflicting interests of one sort and another have prevented the carrying out of efficient work.

One of the greatest difficulties which any local board of health has to contend with in trying to put the municipality under its care in proper condition to-day is the finding of the proper sort of men to carry on the work of inspection and protection of the public health. There is not in the United States to-day any means of providing the training which is necessary for an executive health officer or health inspector, and we are continuously confronted in the community in which I live — Montclair, N. J. — with that fact. Every few years we have to go through the finding of a new man to occupy the position of executive health officer. We are in that position to-day. We had in Montclair a few years ago an outbreak of typhoid fever which resulted in something over eighty cases, — a milk epidemic — due to a mild case of typhoid in the family of a milkman. It was the case of a young man who worked in the dairy and who went to a privy which was located a little higher than a well, from which water was drawn to wash the milk cans, etc. We had, as I say, in Montclair some eighty cases, and they were all on one milk route. And this illustrates the fact that the burden of this responsibility for typhoid does not all rest upon the water works men, although water is generally at the bottom of the matter. That epidemic aroused public interest so much in Montclair that they have backed up the work of the board of health ever since, and we have had almost without exception during the last eight or ten years a trained man as executive health officer in the town. We have generally gone to Professor Sedgwick at the Massachusetts Institute of Technology

and asked him to find some man for us, because the course there and the work under Professor Sedgwick and formerly under Professor Drown seemed best to fit men for that position. But every two or three years the man we get becomes so valuable that he is sought for other lines of work elsewhere and given greater compensation. We have just lost a man who has gone on to the United States Geological Survey to assist in the work of the investigation of water supplies and their pollution. And so we are again confronted with the necessity of finding a competent man, and there is no place to go where we can find a number of men to draw upon for that work.

This Association and its members have an opportunity for a great deal of usefulness in bringing the attention of the public authorities to these other phases of water pollution resulting in typhoid fever epidemics, and also in bringing home to our educational institutions their duty towards the smaller communities in which they are located, and the need of courses in all of our leading institutions of learning which shall fit men to carry on the health protective work of our cities and towns.

PRESIDENT BROOKS. I have noticed that that old fallacy which was advanced by Franklin years ago in England as to the ability of running water to purify itself by oxidization in going a certain distance seems to have more vitality than any error I ever knew of. People living on water drainage areas discharge their filth into the water supply with the idea that it will become perfectly harmless by running a short distance. Do you not find that idea to exist quite generally, Dr. Soper?

DR. SOPER. I do, indeed.

PRESIDENT BROOKS. It seems to be something which has become thoroughly instilled in the minds of many people, especially those living in the rural districts; they seem to feel that filth can be cast into a running stream with perfect impunity. I might say also, in connection with what Mr. Baker has said in regard to the coöperation of local boards of health, that we find it very difficult to interest the boards of health of adjoining towns in the welfare of their neighboring cities. They may be interested in their own affairs, but if our water supply is collected in their towns they take very little interest in preventing its pollution.

We may say to them that their people visit us, and that our people visit them, and that there is an intimacy between the people of the different communities which makes it incumbent upon them to guard our supply as jealously as their own, but that does not seem to have any force with them. Here in New England, where our milk supply comes from adjoining towns, our local board has nothing to do with the conditions under which the milk is furnished, and it really seems sometimes as though if any really efficient work is to be done, it will devolve upon the state to do it.

PROCEEDINGS.

TWENTY-THIRD ANNUAL CONVENTION.

HOLYOKE, September 14, 15, 16, 1904.

The Twenty-third Annual Convention of the Association was held in Holyoke, Mass., on Wednesday, Thursday, and Friday, September 14, 15, and 16, 1904. The headquarters of the Association during the convention were at the Hotel Hamilton, and the meetings were held in a hall in the hotel.

The following members and guests were registered:

MEMBERS.

S. A. Agnew, Kenneth Allen, F. E. Appleton, M. N. Baker, C. H. Baldwin, L. M. Bancroft, F. A. Barbour, H. K. Barrows, G. W. Batchelder, J. E. Beals, J. F. Bigelow, F. E. Bisbee, George Bowers, E. C. Brooks, James Burnie, G. F. Chace, R. C. P. Coggeshall, M. F. Collins, C. E. Colver, W. R. Conard, F. H. Crandall, G. K. Crandall, G. E. Crowell, L. B. Cummings, E. R. Dyer, E. A. Ellsworth, August Fels, B. R. Felton, E. H. Foster, A. M. French, F. L. Fuller, D. H. Gilderson, T. C. Gleason, A. S. Glover, F. W. Gow, J. D. Hardy, L. M. Hastings, V. C. Hastings, A. R. Hathaway, W. C. Hawley, Rudolph Hering, H. G. Holden, R. E. Horton, J. A. Huntington, E. W. Kent, Willard Kent, G. A. King, E. S. Larned, F. H. Luce, T. H. McKenzie, Hugh McLean, D. A. Makepeace, T. W. Mann, A. E. Martin, John Mayo, F. E. Merrill, F. L. Northrop, O. E. Parks, Washington Paulison, H. D. Parsons, H. E. Perry, A. E. Pickup, S. P. Senior, E. M. Shedd, J. Herbert Shedd, C. W. Sherman, M. A. Sinclair, G. H. Snell, G. A. Soper, H. T. Sparks, H. W. Spooner, J. F. Sprengel, G. A. Stacy, J. J. Sullivan, R. J. Thomas, J. L. Tighe, C. K. Walker, C. S. Warde, Timothy Woodruff, G. E. Winslow.

— 80.

ASSOCIATES.

Ashton Valve Co., by C. W. Houghton; Builders Iron Foundry, by A. B. Coulters; Chadwick-Boston Lead Co., by C. N. Fairbairn; Chapman Valve Mfg. Co., by Herbert E. Stone, Edward F. Hughes and E. L. Ross; Coffin Valve Co., by H. L. Weston; Henry A. Desper; Garlock Packing Co., by F. E. Putney; Fred C. Gifford; Greenwood & Daggett Co., by G. F. Chace and W. H. Greenwood; Hart Packing Co., by Horace Hart; Hersey Mfg. Co., by J. A. Tilden, Albert S. Glover, F. A. Smith and H. D. Winton; International Steam Pump Co., by Charles B. Moore and Samuel Harrison; Kennedy Valve Co., by M. J. Brosnan; Lead Lined Iron Pipe Co., by T. E. Dwyer and Franklin Baneroft; Ludlow Valve Mfg. Co., by H. F. Gould; H. Mueller Mfg. Co., by F. B. Mueller and W. L. Dickel; National Meter Co., by Chas. H. Baldwin and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey, C. A. Vaughan and D. B. McCarthy; Norwood Engineering Co., by H. W.

Hosford; Pittsburg Meter Co., by T. C. Clifford; A. W. Chesterton & Co., by Wm. M. Rea; Rensselaer Mfg. Co., by F. S. Bates and Charles L. Brown; Ross Valve Co., by Wm. Ross; A. P. Smith Mfg. Co., by Anthony P. Smith, D. F. O'Brien and F. N. Whitecomb; Sumner & Goodwin Co., by H. A. Gorham; Sweet & Doyle, by H. L. DeWolfe; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by F. L. Northrop and W. F. Hogan; U. S. Cast Iron Pipe & Foundry Co., by W. B. Franklin; R. D. Wood & Co., by Chas. R. Wood and W. G. Woodburn. — 47.

GUESTS.

Mrs. E. C. Brooks, Mr. & Mrs. James P. Bacon, Wm. H. Cutler, Cambridge; Allen M. Pierce, Harry H. Atkinson, F. A. Leavitt, Charles Wilson, T. P. Taylor, Edward Atkinson, Mrs. Horace Hart, Miss J. M. Ham, Boston; Mrs. A. E. Gardner, Mrs. J. E. Burden, Mrs. J. H. Cushing, Middleboro; Mrs. D. H. Gilderson, Haverhill; Mrs. John Mayo, Bridgewater; F. J. Gifford, T. F. Monaghan, Fall River; Mrs. George A. Stacy, Mrs. J. F. Bigelow, Mr. & Mrs. A. E. Longley, Hon. F. R. S. Mildon, W. H. Osgood, A. H. Coughlin, Marlboro; Mrs. Edward L. Ross, Mr. & Mrs. Chas. O. Churchill, Mr. & Mrs. C. A. G. Winther, Mr. & Mrs. F. L. Lane, G. Doran, Indian Orchard; T. J. Gavin, Watertown; George C. Hunt, Worcester; F. S. Dewey, Jr., John L. Hyde, G. W. Rosaback, S. W. Hildreth, Westfield; Charles F. Merrill, Somerville; Mrs. A. E. Martin, Mrs. Charles A. Kilburn, Rufus Fuller, F. A. Holden, Charles Davis, M. J. Harrington, E. A. Helmick, Edward P. Butts, Springfield; W. H. Wilcox, A. L. Wright, P. J. Moriarty, H. E. Gaylord, R. F. Kennedy, M. J. Moriarty, South Hadley Falls; E. L. Arundel, Lawrence; M. Schofield, E. W. Bigelow, Webster; Mrs. George Bowers, Miss Helen E. Bowers, Mrs. F. E. Appleton, Mrs. R. J. Thomas, R. J. Crowley, Grover Fels, F. L. Weaver, Alvah Weaver, M. J. Dowd, P. Kelley, E. W. Lovejoy, Lowell; Mrs. George E. Winslow, Mrs. Fred C. Gifford, Waltham; Mrs. H. W. Hosford, Florence; Mrs. H. B. Hamilton, Chester; Mr. & Mrs. C. G. Howe, Orange; George M. Hawkes, Portland; J. Emerson, Bangor, Me.; George Goodhue, Concord, N. H.; Mrs. Willard Kent, Narragansett Pier, R. I.; C. B. Crowell, Brattleboro, Vt.; C. A. Goodhue, H. R. Cooper, Mrs. P. J. Sullivan, James Hosfall, John Hosfall, Thompsonville, Ct.; George F. Bard, Norwich, Ct.; Mr. & Mrs. J. M. Kinder, Meriden, Ct.; Mr. & Mrs. E. G. Smith, Beloit, Wis.; H. C. Jenkins, New Milford, N. Y.; W. E. Lincoln, New Berg, N. Y.; J. Grace Billings, Cambridge, N. Y.; A. R. Foley, Trenton, N. J.; J. C. DeMello, Jr., New Bedford, Mass.; Mrs. Washington Paulson, Passaic, N. J.; Mrs. F. H. Luce, Wood Haven, N. Y.; W. C. Hopper, Paterson, N. J.; T. J. Nagle, Erie, Pa.; J. F. O'Brien, New York City; Alice S. Corner, W. E. White, F. H. Evans, P. J. Lucey, F. J. Millane, Alexander O'Brien, J. F. Curvan, W. B. Reid, Mrs. E. A. Ellsworth, T. H. Sears, A. C. Edson, E. M. Dickinson, George H. Miller, A. Davis, W. J. Howes, Thomas Stansfield, John J. Kirkpatrick, Elizabeth Sullivan, Ella G. Partridge, Marion B. Corner, Annie L. Kelton, Louise Tower Dickinson, Millie D. French, Patrick Gear, Thomas E. Bligh, H. E. Fuller, John Stalker, Wm. G. Lee, Theo. L. LaFrance, W. H. Abbott, M. F. Walsh, Lillian A. Utley, W. D. Ballard, James M. Kennedy, V. E. Hastings, W. H. Whitecomb, Mrs. J. J. Sullivan, J. J. Dunn, Hon. Arthur B. Chapin, Homer J. Stratton, A. E. DeWolfe, R. P. Cunningham, Chas. L. Newcomb, W. M. Reynolds, W. J. Sumner, Robert E. Newcomb, Albert E. Denison, J. M. Kearns, I. R. C. Winchester, A. F. Sickman, S. E. Whiting, L. E. Connell, George Nightingale, Joseph K. Barber, E. D. Lombard, John C. Dickinson, F. M. Sears, S. B. Slayton, A. D. Cooke, A. K. Wheeler, C. D. Powers, W. V. McCarthy, H. A. Wheeler, C. N. Wheeler, C. L. Allen, F. H. Metcalf, F. A. Smith, John S. Hildreth, Mrs. W. G. Dwight, R. H. Cahill, G. H. Smith, Frank A. Woods, E. Hart, C. Range,

Mrs. W. Bradford, Ashton E. Hemphill, W. E. Sauvin, Thomas Moynihan, Frank Feather, N. P. Avery, Charles W. Haworth, M. J. Alyson, Patrick H. Carey, James F. Cleary, Charles E. Mackintosh, A. P. Capin, Terrace O'Donnell, G. L. Bosworth, W. C. Livermore, John J. Dowdall, Frank Quigley, N. W. Hart, C. P. Lyman, Edward Stratton, Ralph G. Waite, C. F. Thranhardt, Mr. & Mrs. Thomas Appleton, Holyoke, Mass. — 192.

(Names counted twice. — 4.)

WEDNESDAY, SEPTEMBER 14.

The Convention was called to order at 11 A.M. by President Edwin C. Brooks, who introduced Mayor A. B. Chapin of Holyoke. The mayor spoke as follows:

ADDRESS OF WELCOME BY MAYOR CHAPIN.

Mr. President, Ladies and Gentlemen, — It is proper that when we are extending to the members of the New England Water Works Association a most cordial greeting to our city, the condition of the atmosphere should be such as it is, — not to throw any wet blanket upon the success of your meeting, but to show you that we in Holyoke are great believers in water. (Laughter.) But I know that the committee have arranged it so that when you go around to inspect our beautiful city the sunshine will be turned on. Our city is one that has been built up, I may say, by water. The Connecticut River has been harnessed to turn rags into paper, to manufacture cloth and thread and machinery and the other products of our factories which have made Holyoke what she is to-day, not only famous as the city where the best writing paper in the world is made, but also one of the leading cities in this section in all lines of manufacture.

Your Association is interested in water, not as it is used for manufacturing purposes, however, but in its relations to the municipality. One of the greatest problems which can confront any city is the obtaining of a pure water supply. We are fortunately situated in that respect here, being on a side hill, so that we can take the waters as they come down from the hills and mountains above us. We are by nature provided with an adequate supply, and our water commissioners have utilized the sources of supply in such a way that we believe they will be ample for our needs for a great many years to come. While other cities

are still compelled to face serious questions in connection with their water supply and drainage, involving large expenditures of money, we feel that those questions have been solved here satisfactorily. We trust that you will be benefited by your visit to us, and that we may also be benefited by your presence among us and by the new ideas which we may gain from our intercourse with you. (Applause.)

Mr. M. H. Whitcomb, president of the Holyoke Business Men's Association, was then presented by President Brooks, and he spoke as follows:

ADDRESS OF WELCOME BY M. H. WHITCOMB, PRESIDENT HOLYOKE
BUSINESS MEN'S ASSOCIATION.

Mr. President, Mr. Mayor, Ladies and Gentlemen,— Since it was fully decided that we were to have the honor and pleasure of having you as our guests here in Holyoke, I have tried to think of something to say which would fittingly express the cordial welcome which is in our hearts. But as I have listened to the words of our honored mayor I have felt that I could add nothing to what he has so well and ably said. If I made the attempt it would only be repetition, and would be taking time which I know you desire to devote to matters of greater interest and profit than listening to anything I might say. I was reading recently an incident related of a citizen who suddenly appeared in more prosperous circumstances than usual, and he was hailed by an acquaintance with the salutation, "Hello, Mr. O'Brien; I see you have a nice gold watch and chain, and you are looking pretty prosperous to-day." O'Brien replied, "I guess you haven't heard the news. It's my own iligant self that has married the richest widdy in town, and I *inherited* these things from the husband she had before me." (Laughter.) Therefore, in behalf of the Association which I represent, I will inherit as my own the sentiments his Honor has so well expressed. (Laughter.)

It is much more becoming that we should listen to your discussions of the very vital and important matters relating to a pure and wholesome water supply than that I should bore you with any remarks. I have read that if one has nothing new,

pertinent or interesting to say, he had better not say anything and thereby avoid distressing his hearers and embarrassing himself. That is good advice. I recall an incident related of a clergyman who addressed a Sunday-school class upon a subject with which he desired them to become familiar. At the close of his remarks he asked, in a very paternal and patronizing way, "Is there any little boy or any little girl who would like to ask a question?" Receiving no response he repeated his query, whereupon a shrill, piping little voice from the rear of the room called out, "Please, sir, you said that the angels walked up and down Jacob's ladder, and you said that they had wings. Now, if they had wings, what made them walk?" (Laughter.) The parson about that time was regretting that he hadn't sat down earlier, but he finally said, "Oh, yes, I see. And now is there any little boy or any little girl who would like to answer little Mary's question?" Well, I am going to sit down now, sincerely hoping that we may be successful in accomplishing what we have aimed at, and that is to make your visit with us so pleasant that it will be long remembered by you all and something to date from in the future. (Applause.)

President Brooks then called on Mr. John J. Sullivan, chairman of the Board of Water Commissioners, Holyoke, who responded as follows:

ADDRESS OF WELCOME BY MR. J. J. SULLIVAN, WATER COM-
MISSIONER.

Mr. President, Mr. Mayor, Ladies and Gentlemen, — You have already been extended the privileges of the city by his Honor Mayor Chapin and by the Hon. M. H. Whitcomb, president of the Business Men's Association, and I can assure you that it is with great pleasure I extend to you a most cordial welcome in behalf of our Board of Water Commissioners. We perhaps more than others realize the importance of your meeting in Holyoke. We realize that attending here are those whose time is very valuable, but they recognize the importance of that which has often been called "God's free-gift," and they are willing to give their time and to put their knowledge with that of others in considering and

devising means for the improvement of our public water supplies. By the inconvenience to which you are oftentimes put, and by the expense and loss of time which many of you oftentimes incur in attending these conventions, you have demonstrated your sincerity and your loyalty to this Association and what it represents, and are doing much to impress the public with the fact that a water supply is not a mere plaything, but a matter of great importance. I take this opportunity, Mr. President, to thank you and your committee and your entire Association for your courtesy and consideration in choosing the city of Holyoke as the place for your annual convention this year. We consider it a great advantage and a great honor to us to have you here. (Applause.)

PRESIDENT BROOKS. *Mr. Mayor, Mr. Whitcomb, and Mr. Sullivan*,—On behalf of the New England Water Works Association I thank you sincerely for your cordial welcome to the city of Holyoke, and I am sure that when we go from here the universal verdict will be that it is well that we came.

NEW MEMBERS ELECTED.

The Secretary read the following names of applicants for membership, all of whom had been duly recommended by the Executive Committee:

For Resident Member. — Augustus B. Palmer, Franklin, Mass., Superintendent Franklin Water Co.; George Warren Hawkes, Portland, Me., Superintendent Meter Department; Harry E. Green, Waterville, Me.; Albert S. Hall, Waterville, Me., Superintendent Kennebec Water District; George C. Hunt, Worcester, Mass., Water Registrar; D. H. Parsons, Westfield, Mass., Superintendent Westfield Water Works; Robert J. Crowley, Lowell, Mass., President Lowell Water Board; Leonard C. Robinson, Waterville, Me., Kennebec Water District; Frank E. Winsor, Boston, Mass., with Charles River Basin Commission; Leonard P. Wood, Boston, Mass., with Charles River Basin Commission.

For Non-Resident Member. — Elizabeth Moran Finnegan, Lyons, N. Y., Superintendent and Secretary of the Lyons Water Works Co.; Ulrich Taubenheim, Archangel, Russia, Manager and

Chief Engineer, Archangel Water Works; Erastus G. Smith, Beloit, Wis., chemist and bacteriologist.

For Associate. — Henry A. Desper, Worcester, Mass., manufacturer of water meters and other hydraulic appliances.

On motion of Mr. Fels the Secretary was instructed to cast one ballot in favor of the applicants, which he did, and they were declared elected.

COURTESIES EXTENDED.

The Secretary announced that the Entertainment Committee of the citizens of Holyoke had arranged for members of the Association to visit the plants of any of the following named companies on Wednesday and Thursday: Coburn Trolley Track Mfg. Co.; Holyoke Machine Co.; Holyoke Water Power Co.; Holyoke Steam Boiler Works, Inc.; Holyoke Street Railway Co.; Holyoke Valve & Hydrant Co.; J. & W. Jolly, paper mill machinery manufacturers; Lyman Mills; National Blank Book Co.; George W. Prentiss & Co., wire manufacturers; Whitmore Mfg. Co.; American Thread Co.; and that arrangements had been made to visit on Friday, in parties of eight or ten persons, each party in charge of members of the Entertainment Committee, the following named paper mills: American Writing Paper Co., Albion, Crocker, Linden and Riverside No. 2 Mills, Carew Mfg. Co., Parsons Paper Co., Whiting Paper Co.

The Secretary read letters from the following:

Secretary of the Board of Fire Commissioners, inviting an inspection of fire-engine houses and apparatus.

Coburn Trolley Track Mfg. Co., inviting members to visit the works of the company at Willimansett.

Commodore of the Holyoke Canoe Club, extending the privileges of the club house and fleet for one week.

Chapman Valve Mfg. Co., extending an invitation to visit and inspect the works at any time convenient to the members.

Secretary of the Holyoke Club, extending, by vote of the board of directors, the hospitality of the club and the use of the club house.

On motion of Mr. F. H. Crandall it was voted to accept the

invitations, and that the thanks of the Association be expressed to the various companies, firms, and organizations.

It was further announced that the Entertainment Committee of the citizens of Holyoke had made arrangements for conveyances to take the members of the Association to the various points of interest.

The Secretary read the following communication from the water commissioners of the city of Taunton:

TAUNTON, MASS., May 21, 1904.

TO THE NEW ENGLAND WATER WORKS ASSOCIATION:

Gentlemen, — We, the Board of Water Commissioners of the city of Taunton, desire to extend to the members of your Association an acknowledgment of their effective coöperation in the effort which resulted in the defeat of the recently proposed legislation embodied in what is now generally known as the Assawompset bill. Not alone was the safety of Taunton assailed, but the water supply of every city and town in the Commonwealth was threatened.

Though the interests of our city and of the cities and towns which you represent are identical, we recognize with especial gratitude the unfaltering unanimity with which you came to our support when the attack assumed a special rather than a general character. A large share of the effort which was made, resulting in the defeat of this dangerous if not pernicious legislation, stands to your credit, and we should be recreant to our sense of justice were we to fail to express in this formal manner our deep and grateful appreciation of your interest in our behalf.

We beg to remain,

Very truly and respectfully yours,

BOARD OF WATER COMMISSIONERS OF THE CITY OF TAUNTON,

By HENRY M. LOVERING, *President*.

The Secretary read a letter from R. D. Wood & Co., calling attention to the importance of uniformity of hydrant nozzle threads and threads for hose connections, and suggesting the appointment of a committee to join with committees from water and fire insurance associations in discussing and settling upon some standard.

THE PRESIDENT. I think every one who has had to do with fire apparatus or hydrants must realize that something is needed in the way of uniformity, instead of the multiplicity of threads and sizes that there are at the present time. I think it is evident that in these days of quick transit and means for rapid transportation, when cities are calling upon other cities sometimes at a remote distance for help in times of great conflagrations, interchangeable hose and hydrant threads would greatly facilitate the

work of the fire departments. I realize as well as any one that it is going to require great effort to get departments to change their equipment, but it seems to me that it is time now to make a beginning. The fire engineers have appointed a committee in years past to consider this subject, but not much has yet been accomplished. The civil engineers have done something in the way of proposing a system, but I do not know with what success they have met. Now, the New England Water Works Association proposes to appoint a committee,* and we hope that some good may come from our efforts. That committee will consist of Messrs. George A. Stacy of Marlboro, M. F. Collins of Lawrence, and Lewis M. Bancroft of Reading. I hope we will hear something from that committee in the near future which will encourage us to go on with the good work.

There being no further business to come before the meeting, an adjournment was had to two o'clock.

At the opening of the afternoon session a communication was received from the Deane Steam Pump Company inviting members to visit its works, and announcing that free automobile transportation would be furnished all those who desired to accept.

The first paper of the afternoon was by Mr. Albert F. Sickman, hydraulic engineer, Holyoke Water Power Company, Holyoke, Mass., giving a history of the development of the water power of Holyoke.

Mr. R. C. P. Coggeshall, superintendent water works, New Bedford, Mass., then read a paper entitled "Up to 1895 — Some Reminiscences." On motion of Mr. Joseph E. Beals a vote of thanks was extended to Mr. Coggeshall for his very interesting paper.

At the evening session, Mr. Rudolph Hering of New York presented a paper on "The Additional Water Supply of New York." This was followed by a paper entitled "Municipal Water Supply Revenue," by James L. Tighe, city engineer, Holyoke, Mass. The paper was discussed by Mr. M. N. Baker of New York, and Mr. Hugh McLean, water commissioner of Holyoke.

* See Proceedings of Executive Committee, May 19, 1904. JOURNAL, September, 1904, p. 333.

Mr. Kenneth Allen, engineer and superintendent of the Atlantic City, N. J., Water Department, described "A Wood-Stave Conduit for the Water Supply of Atlantic City." The subject was discussed by Mr. F. L. Fuller, Mr. W. C. Hawley, and others.

Adjourned on motion of Mr. George A. Stacy.

THURSDAY, SEPTEMBER 15.

At the opening of the session on Thursday morning the names of the following applicants for membership were presented:

For Resident Member. — Elbert E. Lochridge, Springfield, Mass., Sanitary Engineer Springfield Water Department.

For Associate. — Hays Mfg. Co., Erie, Pa., manufacturers of gas, water, and plumbers' supplies; Bard Union Co., of Norwich, Conn., manufacturers of the Bard patent union.

On motion of Mr. Fuller the Secretary was empowered to cast one ballot for the applicants, which he did, and they were declared elected.

The next business in order was the appointment of a committee to nominate officers for the ensuing year. On motion of Mr. Robert J. Thomas it was voted that the President be given power to appoint a committee of five.

THE PRESIDENT. A sub-committee of the Executive Committee was appointed some time since to report to the full committee a list of names for honorary membership in this Association. That sub-committee has reported, and the Executive Committee has confirmed its action and now recommends the election of Desmond FitzGerald of Brookline, Mass.; Prof. William T. Sedgwick of Boston; Charles Hermany of Louisville, Ky.; William Booth Bryan of London, England; and J. James R. Croes of New York City, as honorary members.

Mr. M. F. Collins moved that the Secretary cast one ballot in favor of the gentlemen named. The President called upon Mr. Charles W. Sherman to make some remarks, and Mr. Sherman said:

MR. CHARLES W. SHERMAN. I do not know as there is very much for me to say at this time, Mr. President. I think nearly all the gentlemen named are well known to members of the

Association. All of them, with the exception of Mr. Hermany, are now active members, and they are men whom we will do well to honor; and the Association in honoring them will honor itself. Mr. Hermany is, perhaps, with the exception of Mr. Bryan, less well known to us than the others, as he lives in a more distant section of the country. He has been the engineer and superintendent for the Louisville, Ky., Water Company for many years. He is at present the president of the American Society of Civil Engineers, and he ranks with the other gentlemen whose names have been presented as one of the eminent hydraulic engineers of this country. Mr. Bryan is, as you doubtless know, the chief engineer of the London Metropolitan Water Works, recently formed to replace the several private companies which have hitherto furnished water to that city.

Mr. Collins' motion was adopted, the Secretary cast the ballot, and the gentlemen whose names were reported by the committee were declared elected.

The first paper of the morning was by Mr. George A. Soper of New York City, and was entitled "The Epidemic of Typhoid Fever at Ithaca, New York." The address was illustrated by many stereopticon views. Remarks were made, following the address, by Mr. Frank L. Fuller, Mr. L. M. Hastings, Mr. Edward Atkinson, Prof. E. G. Smith, Mr. M. N. Baker, and President E. C. Brooks.

At the afternoon session the Fairbanks Company of Boston, manufacturers of fire hydrants, gate valves, and water works supplies, was elected to associate membership.

Mr. E. H. Foster, mechanical engineer, New York City, presented a paper on "The Use of Superheated Steam in Pumping Engines." Mr. J. Herbert Shedd, Mr. Edward Atkinson, Mr. W. C. Hawley, and President Brooks spoke upon the subject discussed in the paper.

"Bog Fuel" was the subject of an address by Mr. Edward Atkinson, president of the Boston Manufacturers Mutual Fire Insurance Company. At the conclusion of his address Mr. Atkinson exhibited samples of the fuel and answered questions asked by Mr. T. H. McKenzie, Mr. Frank L. Fuller, and others.

Mr. J. Herbert Shedd, of Providence, R. I., read a paper on "The Norwich Compressed Air Plant." The discussion of the subject was participated in by Mr. Edward Atkinson, Mr. T. H. McKenzie, Mr. Frank L. Fuller, and Mr. Albert F. Sickman.

In the absence of the chairman, Mr. Robert J. Thomas submitted an informal report for the Committee on Private Fire Services.

The Convention adjourned without taking any action upon the report of the committee.

At the opening of the evening session Mr. Frank E. Merrill, who had charge of the exhibits of associates, made his report. He said, —

Before presenting the list of exhibitors I wish to refer for a moment to our late associate and friend, Mr. Henry F. Jenks, who for so many years has had charge of the exhibits and attended so well to the duties which I have this year been called upon to perform. When our Secretary asked me recently if I would help him out in this matter, he referred to the disability of Mr. Jenks; I thought then that it was an illness of a temporary nature, and that we should soon see him about again, and I was greatly shocked when three days ago I read the announcement of his death. Mr. Jenks was an inventor of considerable reputation, a man of pleasing personality, and a member of this Association who has always endeavored to advance its interests. He will be greatly missed by us all. I will now make the following report:

The following is a list of the exhibitors at the twenty-third annual convention of the New England Water Works Association, at Holyoke, Mass., September 14, 15, 16, 1904.

1. A. P. Smith Mfg. Co., Newark, N. J., pipe tapping machinery; stop-cocks and brass fittings.
2. Bard Union Co., Norwich, Conn., removable ground brass seat unions and flanges.
3. Chapman Valve Mfg. Co., Indian Orchard, Mass., hydrants, gates, and valves.
4. Coffin Valve Co., Neponset, Boston, Mass., hydrants; service boxes.
5. The Fairbanks Co., Boston, Mass., hydrants; valves.
6. Greenwood & Daggett Co., Boston, Mass., steam packing; water works specialties.
7. Hayes Mfg. Co., Erie, Pa., service boxes; stop-cocks; brass fittings.
8. The Hart Packing Co., Boston, Mass., steam packing.
9. Hersey Mfg. Co., Boston, Mass., water meters.

10. Holyoke Valve & Hydrant Co., Holyoke, Mass., fire hydrants.
11. Kennedy Valve Mfg. Co., New York.
12. Lead Lined Iron Pipe Co., Wakefield, Mass., lead and tin lined iron pipe and fittings.
13. H. Mueller Mfg. Co., Decatur, Ill., service tapping machines; stop-cocks; plumbers' supplies.
14. National Meter Co., New York, water meters.
15. Neptune Meter Co., New York, water meters.
16. Norwood Engineering Co., Florence, Mass., hydrants; gate boxes; valves.
17. Pittsburg Meter Co., East Pittsburg, Pa., water meters.
18. Thomson Meter Co., New York, water meters.
19. Union Water Meter Co., Worcester, Mass., water meters; pressure regulator valves; stop-cocks.
20. R. D. Wood & Co., Philadelphia, Pa., hydrant; gate; indicator post.
21. Henry R. Worthington, New York, water meters.

Respectfully submitted,

FRANK E. MERRILL,

In Charge of Exhibits.

Mr. A. M. French, water commissioner, Holyoke, Mass., then read a paper on "The Holyoke Water Supply."

Mr. Herman W. Spooner, engineer of the Gloucester water works, was the next speaker, and he gave an informal talk describing the Haskell Brook Reservoir Dam, at Gloucester, illustrating his description by a large number of stereopticon views.

Mr. George A. King, superintendent of the water works at Taunton, Mass., read a paper entitled, "The Direct Pumping Method of Water Supply in Use at Taunton."

The report of the Committee on Uniform Statistics having been called for by the President, Mr. Joseph E. Beals, chairman of the committee, said that the committee had held no formal meeting during the year, although the members had met informally and talked the subject over, and that all they had to report now was progress, or, perhaps he might say, lack of progress. He suggested that something might be done the coming year. The President announced that the committee would be continued.

The President said there was no more business to come before the convention at this time. "I think," he said, "we may felicitate ourselves on this having been one of the most successful conventions in the history of the Association. It has been a great pleasure to me to see the large attendance at our meetings, and I thank you all very heartily for your presence and attention."

On motion of Mr. Joseph E. Beals the convention adjourned.

FRIDAY, SEPTEMBER 16.

Through the courtesy of the Board of Water Commissioners and the Business Men's Association of the city of Holyoke, the morning was devoted to visiting the famous paper mills of the city, under escort of members of the Reception Committee. In the afternoon the members of the Association and their guests were taken to the summit of Mt. Tom, where luncheon was served, after which President Brooks called the company to order and announced the committee on nominations as follows: John C. Chase, of Derry, N. H.; William E. Maybury, of Braintree, Mass.; George A. King, of Taunton, Mass.; J. D. Hardy, of Holyoke, Mass., and J. C. Whitney of Newton, Mass. He then said:

"Gentlemen, before we separate I want to say, and I know you will all agree with me, that we feel very grateful to the citizens of Holyoke, to the members of the Business Men's Association and to the Water Board for what they have done for us, which has made our convention one of the most successful that the Association has ever held. I know that we will all go away from this city with the very kindest recollections."

MR. CHARLES W. SHERMAN. I think it would not be stretching the truth to say, Mr. President, that this has been the most successful convention that the Association has ever had. I know it is the largest in registration, partly because of the interest which our Holyoke friends have shown by appearing at our meetings, the local attendance having been larger than ever before to my knowledge; but even without the Holyoke attendance the convention has been one of the most largely attended in our history, and it has been most satisfactory in every respect. I wish to offer the following resolution:

Voted, That the thanks of the New England Water Works Association be extended to the Reception Committee of the citizens of Holyoke, and through them to the Mayor, the Board of Water Commissioners, the Business Men's Association and the other associations, clubs, corporations, and individuals, whose hospitality and unremitting attention have so materially contributed to make this one of the most successful conventions in its history.

MR. FRANK E. MERRILL. Mr. President, I am glad most heartily to second this motion, and in doing so I wish to express my profoundest admiration for the city of Holyoke, for its beauty, for the hospitality of its officials and its private citizens, and for the glorious weather which they have given us during our stay here, all of which have contributed so greatly to our pleasure.

MR. AUGUST FELS. Mr. President, I have been at every convention which the Association has held for the past nine or ten years, and I never have enjoyed one as much as I have this. I was in Holyoke forty years ago. At that time there were only one or two manufacturing concerns here, and I must confess my amazement at the rapid growth and development of the city. I wish also to second the motion.

The motion was adopted with great enthusiasm, and the President said he was sure that the Holyoke friends could have no doubt that it was the unanimous vote of the members of the Association that they had all had a grand time.

MR. A. M. FRENCH. *Mr. President, Members of the New England Water Works Association, Ladies and Gentlemen,* — In behalf of the Water Department of Holyoke I return to you our most hearty thanks for your expression of appreciation. I have now the pleasure to present to you the secretary of the Holyoke Board of Water Commissioners, Mr. Hugh McLean, who will in a somewhat more formal manner express our thanks for your very kind and courteous vote.

MR. HUGH McLEAN. *Mr. Chairman, Ladies and Gentlemen,* — At this period of what has proved a very successful and enlightening, as well as entertaining, convention, it would appear that any extended remarks by me would be unwarranted. My duty ought to be, perhaps, to pronounce the benediction, and wish you Godspeed and safe return to your homes and vocations. However, I may be pardoned for referring to the high standard of your gathering, the excellence of the various addresses, and the incentive to further progress toward perfection in water supply that a gathering of the nature of this convention must be. The addresses of our visitors have been of a high order and instructive, and the papers of Commissioner French and Engineer Tighe

bespeak for themselves the commendation which they will surely receive from their fellow-citizens.

For so young a city as Holyoke, we of her citizenship take what we consider a pardonable pride in her makeup. Nature has been generous to her in the matter of beautiful surroundings, as your inspection of her, even in wet weather garb, and your visit to our delightful old Mt. Tom must have convinced you. Industry has been the keynote of her prosperity; and of this spirit of industry the various gentlemen who in the past have had in charge the matter of water supply seem to have possessed a fair share, the result of which is seen to-day in what we may claim, without undue pride, to be a source of local happiness and satisfaction,—Holyoke's system of water works.

To have sprung, in a half century, from the hamlet to the stirring and — pardon me — beautiful city which Holyoke's sons to-day consider her is a circumstance of no small importance. Within her limits municipal problems of moment have received consideration and solution, and it is hoped to keep her in the front rank of those municipalities which are continually pondering as to how public burdens may be so adjusted that the individual taxpayer may become, what the Lord loves, "A cheerful giver."

That we may continue in successful effort I feel is the wish of this gathering, and ought to be so; for no community in its successes makes accomplishment for itself alone, but becomes as a shining light unto others.

Conventions, therefore, like the one just closed help to diffuse that light along the troublous path of the common want and necessity, pure water, and must be looked upon with favor.

In behalf of the local Board of Water Commissioners, and also of the community, I beg to express our thanks to the visiting gentlemen for their attendance, and to express the hope that the impressions which you will carry away of our city are such that the memory of her will always occupy a welcome place in your recollection.

Again thanking you and all those who so generously contributed to make this convention a successful one, I wish you many more

and hope at some future time we may again be favored by your presence.

Adjourned.

NOVEMBER MEETING.

HOTEL BRUNSWICK,

BOSTON, MASS., November 9, 1904.

Edwin C. Brooks, President, in the chair.

The following members and guests were in attendance:

MEMBERS.

S. A. Agnew, C. H. Baldwin, L. M. Bancroft, F. A. Barbour, George Bowers, E. C. Brooks, G. F. Chace, R. C. P. Coggeshall, M. F. Collins, J. W. Crawford, G. E. Crowell, J. C. Gilbert, A. S. Glover, F. W. Gow, J. O. Hall, J. D. Hardy, T. G. Hazard, Jr., D. A. Heffernan, H. G. Holden, J. L. Howard, E. W. Kent, Willard Kent, G. A. King, C. F. Knowlton, A. B. Lisle, Hugh McLean, D. A. Makepeace, W. E. Maybury, F. E. Merrill, W. W. Robertson, C. M. Saville, C. W. Sherman, M. R. Sherrerd, G. H. Snell, J. T. Stevens, T. V. Sullivan, R. J. Thomas, H. L. Thomas, W. H. Thomas, J. L. Tighe, G. W. Travis, W. H. Vaughn, C. K. Walker, R. S. Weston, F. I. Winslow, G. E. Winslow. — 46.

HONORARY MEMBERS.

Desmond FitzGerald, F. W. Shepperd. — 2.

ASSOCIATES.

Ashton Valve Co., by C. W. Houghton; Harold L. Bond & Co., by Harold L. Bond; Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; Henry A. Desper; Hersey Mfg. Co., by Albert S. Glover and H. D. Winton; The Fairbanks Co., by F. A. Leavitt; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; National Meter Co., by Chas. H. Baldwin and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Perrin, Seamans & Co., by J. C. Campbell; Pittsburg Meter Co., by Edwin A. Knowlton; Rensselaer Mfg. Co., by Fred S. Bates; A. P. Smith Mfg. Co., by F. N. Whitcomb; Sweet & Doyle, by H. L. DeWolfe; Union Water Meter Co., by F. L. Northrop; R. D. Wood & Co., by Wm. F. Woodburn. — 20.

GUESTS.

John N. Cook, Hydraulic Engineer, Paterson, N. J.; Charles A. Maynard, Boston, and E. F. Mullauney, Brookline, Mass. — 3.
(Names counted twice. — 3.)

The following were elected members:

Resident. — Charles L. Bowker, Brunswick, Me., Superintendent Brunswick Water Works; Edward Atkinson, Brookline, Mass.

Non-Resident. — Charles Arthur Hague, New York City, engaged in hydraulic and power work in connection with public water supplies; John H. Gregory, Columbus, Ohio, Engineer of Design and Principal Assistant Engineer in charge of construction of the improved water and sewerage systems, Columbus, Ohio; John C. Trautwine, Jr., Philadelphia, Pa., formerly Chief of the Bureau of Water, Philadelphia.

The Secretary read the following letters from gentlemen who were elected honorary members of the Association at the Holyoke Convention:

YORK HARBOR, ME., October 5, 1904.

WILLARD KENT, Esq.,
Secretary, etc.

Dear Sir, — I yesterday received your kind letter of September 29, notifying me of my election as an honorary member of the New England Water Works Association.

It gives me much pleasure to accept the very high honor which the Association has conferred upon me. I have always felt a deep interest in everything that concerns the welfare of this important and progressive society and have never failed to benefit from attending the meetings.

I hope, now that I have returned to Boston, to be able to meet the members at some of the interesting winter meetings.

Very faithfully yours,

DESMOND FITZGERALD.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
BOSTON, September 30, 1904.

My dear Mr. Kent, — I have before me your kind letter of yesterday, informing me of my election to honorary membership in the New England Water Works Association. I have the honor hereby to accept the election, and I am deeply gratified by this token of regard on the part of an organization of which I have long been proud to be an ordinary member.

The only return that I can possibly make to the Association for the great honor which it has now conferred upon me will be by furthering its interests in every possible way. Believing, as I do, that the great function of the Association is the bringing together of men of similar tastes, engaged in similar pursuits, for the sake of mutual acquaintance, perpetual good fellowship and the instruction and inspiration which result from a collision of ideas, I pledge anew to the Association my good-will and my best services. The Association has done much already to safeguard and improve the water supplies of New England. I believe that it will do much more in the future.

Will you kindly convey to the members of the Association my warm appreciation of their action, and my sincere and respectful thanks for the honor they have conferred upon me.

Very truly yours,

WILLIAM T. SEDGWICK.

TO WILLARD KENT, Esq.,
Secretary New England Water Works Association.

OFFICE OF LOUISVILLE WATER COMPANY,
LOUISVILLE, KY., October 13, 1904.

MR. WILLARD KENT,
Secretary New England Water Works Association,
715 Tremont Temple, Boston Mass.

Dear Sir, — Your favor of the 29th ult. was received on the 10th inst., upon my return from the Annual Convention of the American Society of Civil Engineers and the International Engineering Congress. In it you inform me of my election as an honorary member to the New England Water Works Association, and you request me to signify my acceptance thereof.

In reply I state that I accept the honorary membership and thank the Association and you for the distinction and honor expressed and implied by your action.

Very respectfully,

CHAS. HERMANY,
Chief Engineer and Superintendent.

MORRIS BUILDING, 68 BROAD STREET,
NEW YORK, October 12, 1904.

WILLARD KENT, Esq.,
Secretary New England Water Works Association,
Boston, Mass.

Dear Sir, — I beg to acknowledge the receipt of your letter of September 29 informing me that the New England Water Works Association had done me the honor of electing me an honorary member of the Association.

In accepting such membership, permit me to express my high appreciation of the honor thus conferred upon me by the Association, which has long been looked upon by me as the most thoroughly practical and instructive of the various societies devoted to the design, construction and management of the important water-supply industry. I have long esteemed it a privilege to be a member, and although I have rarely been able to attend the meetings, the papers and discussions published in the JOURNAL have often been of great use to me in my practice.

Very truly your obedient servant,

J. J. R. CROES.

THE PRESIDENT. We have with us this afternoon one whom we have always delighted to honor and are always glad to meet at our meetings, a gentleman of wide and varied experience in water works engineering, construction and management, and I am sure you all join with me in wishing to hear a few words from our old friend, Mr. Desmond FitzGerald. (Applause.)

MR. FITZGERALD. *Mr. President and Fellow Members,* — It is needless for me to say that I am gratified to be again among, I cannot say the same old friends, but very nearly the same old friends, with whom I have been associated for so many years. When I was notified of the very great honor that you did me recently in electing me an honorary member, I cast about in my

mind to find something that I had done which would at all justify your action, but I could not find anything until it finally occurred to me that honorary members are generally selected from among the old men; and I dare say it will be our friend Coggeshall's turn before long. (Laughter.)

It is just about two years ago that I was here with you last, and we then had a little talk on Venice. At that time I did not realize that I should see so much of the world within such a short time; but since that afternoon I have been in Japan and China and the Philippines and a good deal in California, and have seen many things and many places that I knew little about before. It is gratifying to one who travels to find that the influence of the New England Water Works Association is not entirely left behind on leaving Massachusetts. In talking with people in different parts of the world, when I have been told that such-and-such a thing was good in connection with water supplies, it has occurred to me, Why, I heard about that very thing from brother so-and-so, years ago at a meeting of the New England Water Works Association; and very often when matters have come up which required the exercise of judgment, care, and thought, that judgment and care and thought have been very much influenced and aided by what I have learned here at our meetings.

When I made up my mind that it was because I was so old a man that I had been elected an honorary member, I concluded to write something. I hope it will convince you that I am not in my second childhood. (Laughter.)

(Mr. FitzGerald then read the following verses, which were received with much laughter and applause.)

THE NEW SILVER FAUCET.

Dear, dear to my heart are the thirsts of my manhood,
Quenched deep from the pipes of our public supply;
The sources protected by acres of wildwood,
And meadows that stretch far away to the sky.
The long iron pipes that are sunk in the gravel
To gather the waters all filtered below,
The engine and pump — a high-duty marvel —
And e'en the bright faucet all ready to flow,
The new silver faucet, the patented faucet,
The self-closing faucet all ready to flow.

That silver-washed faucet I think is a daisy,
 For often at night when returned from the club
 It soothes the wild throbbings and makes 'em feel aisy
 And ready for wifey, — and that is the rub.
 How quickly I turn it with hand ever wiser,
 The service, high pressure, with screams like a gale,
 Sixty pounds to the inch and a spurt like a geyser,
 And of color .00 on the Nesslerized scale.
 The new shining faucet, the patented faucet,
 The dear leaky faucet that never will fail.

No germs on its bright silvered brim ever prattle,
 No strong English words as one sinks it below,
 To turn it at last with a dextrous rattle
 In thin slippered feet on the soft, slushy snow;
 That old rotten bucket, that germ covered bucket
 Which scattered its poison some ages ago, —
 Ah, me, when I drink from a well in the suburb
 Where stables and drains extend their dark pall,
 My stomach is turned all around in a hubbub
 And I dream of the faucet that sings in the hall.
 A new silver faucet, a guaranteed faucet,
 A self-closing faucet that leaks in the hall.

THE PRESIDENT. I hardly think that Mr. FitzGerald would be really eligible for honorary membership if age was a necessary qualification or requirement.

We are highly favored in having with us this afternoon the president of our sister association, the American Water Works Association, and it gives me great pleasure to present to you President Sherrerd.

MR. MORRIS R. SHERRERD. *Mr. President and Fellow Members of the New England Water Works Association,* — When I made up my mind that I ought to come up to a meeting of the New England Water Works Association I had forgotten that I was president of the American Water Works Association, and it was with the expectation that I was going to meet a lot of nice people and enjoy a good quiet dinner, and not be disturbed by any such assault as your President has just made on me. (Laughter.) It used to be, when I first joined the American Water Works Association, that the New England Association was getting members from our ranks. I have some hope now that the compliment will be returned, for we want the New England Association to be national as well as local. The New England Water Works Association is certainly to be congratulated on its membership, and the American Association has rather followed

after you in a good many particulars. I would mention especially the fact that we hope to move on the same lines in regard to specifications for cast-iron water pipes and as to similar subjects, and I know from the action of the convention in St. Louis last June that the inclination was that on all such subjects we should work in harmony with the New England Association. In fact, it was then suggested that our committee consult with your committee. Certainly, aims of this kind are of particular advantage to water works men. If we can get the whole country calling for material on the same lines, it will be of advantage to all of us.

I know that you are anxious to proceed with your business, and so with merely an expression of my thanks for this honor, I will allow you to proceed. (Applause.)

The first paper of the afternoon was by Mr. F. M. Bowman, structural engineer, Riter-Conley Mfg. Co., Pittsburg, Pa., entitled, "Description and Test of the East Providence Water Tank and Tower." In the absence of Mr. Bowman the paper was read by Mr. Francis W. Dean. The discussion which followed was participated in by Mr. Arthur B. Lisle, Mr. Dean, Mr. Desmond FitzGerald, Mr. Morris R. Sherrerd, President Brooks, Mr. R. S. Weston, Mr. M. F. Collins, and Mr. George F. Chace.

The next paper was by Mr. Caleb Mills Saville, division engineer, Metropolitan Water Works, Boston, describing "Repairs to the Lining of a Small Reservoir at Chelsea, Mass.," and was illustrated by stereopticon views.

The report of the committee on meter rates was called for, but the committee were not ready to present any definite conclusions or recommendations. The general subject was discussed by Messrs. Hugh McLean, Desmond FitzGerald, Morris R. Sherrerd, Robert J. Thomas, R. C. P. Coggeshall, R. S. Weston, Caleb M. Saville, Frank E. Merrill, and Charles W. Sherman.

On motion of Mr. FitzGerald, adjourned.

EXECUTIVE COMMITTEE.

TREMONT TEMPLE, BOSTON,

FRIDAY, August 19, 1904.

Present: President Edwin C. Brooks and Messrs. George A. Stacy, Joseph E. Beals, Lewis M. Bancroft, Frank E. Merrill, Charles W. Sherman and Willard Kent.

An informal discussion was had on matters pertaining to the organization. No business appearing, meeting was adjourned without day.

Attest: WILLARD KENT, *Secretary*.

CONVENTION HALL, HOLYOKE,

September 14, 1904.

Present: President Edwin C. Brooks and Messrs. Lewis M. Bancroft, Frank E. Merrill, Robert J. Thomas, Joseph E. Beals and Willard Kent.

Three applications were received and the applicants recommended for membership.

The President appointed the following committee to investigate and report on "Uniformity of Hose and Hydrant Threads," viz.: George A. Stacy, Michael F. Collins, and Lewis M. Bancroft. Adjourned without day.

Attest: WILLARD KENT, *Secretary*.

CONVENTION HALL, HOLYOKE, MASS.,

September 15, 1904, AT 7.30 P.M.

Present: President Edwin C. Brooks, Messrs. Robert J. Thomas, Lewis M. Bancroft, Horace G. Holden, V. C. Hastings, Edmund W. Kent, Charles W. Sherman, George A. Stacy, Joseph E. Beals, and Willard Kent.

The sub-committee on honorary members, Charles W. Sherman, Horace G. Holden and Willard Kent, reported, recommending Desmond FitzGerald, J. James R. Croes, Prof. Wm. T. Sedgwick, Charles Hermany and Wm. Booth Bryan for honorary membership; and the recommendation was approved by vote of the Executive Committee.

One application for associate membership was received and approved.

Adjourned.

Attest: WILLARD KENT, *Secretary*.

TREMONT TEMPLE, BOSTON, MASS.,

WEDNESDAY, November 9, 1904.

Present: President Edwin C. Brooks and Messrs. Charles W. Sherman, Robert J. Thomas, Frank E. Merrill, Lewis M. Bancroft, George E. Crowell, H. G. Holden and Willard Kent.

Five applications for membership were received and approved.

Report of Committee on Music recommending that no change be made at the present time was received and approved.

Letters of acceptance from Messrs. Desmond FitzGerald, William T. Sedgwick, J. J. R. Croes, and Charles Hermany, recently elected honorary members of the Association, were read.

Adjourned.

Attest: WILLARD KENT, *Secretary*.

OBITUARY.

DENNIS WOODRUFF CLARK, president of the Portland, Me., Water Company since 1873, died in that city on April 18, 1904.

Mr. Clark was born in Farmington, Conn., on May 27, 1819. He was descended from distinguished ancestry of colonial times. He first engaged in business at Buckingham, Iowa, but in 1840 he removed to Platteville, Wis., where he went into the mining and mercantile business. In 1852, he engaged in trade in Sacramento, Cal., under the firm name of Gill, Clark & Co.. In 1854, he went to Portland, Me., and engaged in the ice business, founding the business now conducted by the D. W. Clark Ice Company. Mr. Clark was treasurer of the Leeds & Farmington Railroad, before that road was sold to the Maine Central, and for seven years was a director of the Portland & Ogdensburg Railroad. In addition to the Portland Water Company, he was also President of the Biddeford & Saco Water Company and of the Standish Water and Construction Company. He had been for many years a prominent member of the State Street Congregational Church. In politics he had been successively a Whig, a Free-soiler, and a Republican, but he never accepted or aspired to public office.

Mr. Clark was elected a member of the New England Water Works Association on June 12, 1890.

KILBURN SMITH SWEET, instructor in civil engineering at the Massachusetts Institute of Technology, died on July 15, 1904.

Mr. Sweet was born in Ramsey, Minn., February 25, 1872. He was graduated at the Institute in 1893, and was an assistant and instructor in civil engineering there from graduation until his death. During the summer vacations he had been engaged upon various professional work, including work for the Associated Factory Mutual Insurance Companies, the Metropolitan Water

and Sewerage Board, the Committee on Additional Water Supply for the City of New York, and the U. S. Geological Survey.

He was elected a member of the New England Water Works Association on March 11, 1903.

REUBEN SHIRREFFS, hydraulic engineer of the Great Falls Power Company, Washington, D. C., died on August 31, 1904.

Mr. Shirreffs was born in 1852, and began his professional work as a student with Clemens Herschel, civil engineer, in 1872. Later he was engaged on the Sudbury aqueduct of the Boston Water Works, the Chicago, Burlington & Quincy Railroad, the Holyoke Water Power Company, the Richmond & Allegheny Railroad, the East Jersey Water Company, the Metropolitan Water Works, and the Virginia Electric Railway and Development Company.

He was elected to membership in this Association on March 12, 1890.

HENRY F. JENKS, widely known as an inventor and manufacturer, died at his home in Pawtucket, R. I., on September 11, 1904.

Mr. Jenks was born in Pawtucket on May 12, 1837. He received his education in the Pawtucket schools. After learning his trade, he entered the employ of the Hope Iron Works, Providence, in the construction of engraving machinery. He served through the Civil War as captain of Company H, Ninth Rhode Island Volunteers. At the close of the war he returned to the Hope Iron Works as superintendent of a department. In 1869 he took charge of the shop in Pawtucket established to manufacture the window spring of his invention, and in this work and the manufacture of other inventions of his own he was engaged to the time of his death. He was probably best known to the Association as maker of the well-known Jenks drinking fountain. For many years he had been in charge of the exhibits at the annual conventions.

He was elected an associate of the New England Water Works Association on April 21, 1885.

COL. ALEXANDER MACOMB MILLER, Corps of Engineers, U. S. Army, in charge of the Washington Aqueduct and of the works for the purification of the Washington water supply, died on September 14, 1904, while on a tour of inspection of the works under his charge.

Colonel Miller was born in the District of Columbia, November 1, 1843. He was graduated from the U. S. Military Academy and became first lieutenant in the Corps of Engineers in 1865, and passed through all the intermediate grades to that of colonel. His service included fortification work, harbor improvements on Lakes Superior and Michigan, four years as principal assistant professor of engineering at the Military Academy, six years in command of the Engineer Company at Willets Point, river and harbor improvement work on the Mississippi River and in the Gulf States, and, from 1898 to his death, in charge of the maintenance and improvement of the Washington water supply.

He became a member of this Association on November 14, 1900.

GEORGE PETERS WESCOTT, treasurer and manager of the Portland (Maine) Water Company since 1877, died in that city on October 22, 1904.

Mr. Wescott was born at Bluehill, Me., on December 24, 1842. As a young man he went to California, and remained there, mostly in government service, until 1866, when he came to Portland, and entered into business with his father under the firm name of Joseph Wescott & Son, granite contractors. In 1869 and 1870 he was an alderman and in 1873 mayor of Portland, and he was a state senator from 1883 to 1886. He was a member and ex-president of the Portland Board of Trade, vice-president of the Casco National Bank, director of the Maine Central Railroad, treasurer of the Standish Water and Construction Company, director of the Portland National Bank, president of the Kennebec Light and Heat Company, and of the York Light and Heat Company, and a director in many other enterprises.


Members of the Association who attended either of the Portland conventions will not soon forget the prominent part taken by Mr. Wescott in the entertainment of the Association.

He became a member of the New England Water Works Association on June 16, 1886.

THOMAS MESSINGER DROWN, president of Lehigh University, died at Bethlehem, Pa., on November 16, 1904.

Dr. Drown was born March 19, 1842, in Philadelphia, and received the degree of M.D. from the University of Pennsylvania in 1862. After practicing medicine a short time he turned his attention to chemistry and metallurgy, and studied at Yale and Harvard and in Germany. Upon his return to this country he became instructor at Harvard, but after a year went to Philadelphia where he practiced as an analytical chemist from 1870 to 1874. He was then professor of chemistry at Lafayette College, but resigned this position in 1881 to devote himself to his work as secretary of the American Institute of Mining Engineers. In 1885 he became professor of chemistry at the Massachusetts Institute of Technology, and in 1889, in addition, chemist of the Massachusetts State Board of Health, and as such had a very important part in the investigation of water supplies and the studies of purification of sewage and water which are so well known. In 1895 he became the president of Lehigh University, and in the same year the degree of LL.D. was conferred upon him by Columbia University.

Dr. Drown became a member of this association on June 13, 1888.



BOOK NOTICE.

"Examination of Waters and Water Supplies." By John C. Thresh. Cloth. 8vo. 460 pages, 19 plates, 19 tables, 13 illustrations in text. P. Blakiston's Son & Company, Philadelphia, 1904. Price \$4.

This treatise by Dr. Thresh is the first English work published which discusses thoroughly the character of water, and at the same time describes more or less completely the general problems of water supply from the sanitary standpoint.

The book is divided into three parts, *viz.*:

PART 1. The examination of the sources from which water is derived.

PART 2. Various methods of examining water and the interpretation of the results.

PART 3. Analytical processes and methods of examination.

There is also an appendix containing data for the preparation of reagents and media; various analytical tables; several pages of notes on various subjects, such as the detection of radium in waters, the value of systematical examinations of public supplies, and the question of standards. (The excellent microscopic drawings precede the appendix, and an excellent index completes the book.)

From the beginning the author recognizes the importance of the sanitary inspection of water supplies; perhaps he gives too much weight to this part of the general method for determining the character of a water. Much of the matter in the first five chapters, taken from engineering sources, would be found useful to the chemist, the engineer and the health officer. In general the book is written in a common-sense way. It is a record of the author's wide experience, therefore it is particularly adapted to English readers. It treats rather of practice than principles.

In the chapter on the interpretation of analytical results, the author expresses views which are generally in accord with those held in this country. He is to be commended for disapproving of all water of objectional appearance; but criticism might be made of the statement that yellow colored waters are more likely to be impure than others.

It is unusual and gratifying in an English work to find such wide references to the world's literature. Indeed, the volume has been brought up to date in a remarkable way.

The author makes little or no mention of aeration as a means of odor removal, although he mentions filtration in this connection.

He is the first English author to recognize the importance of microscopical examination of water, and has included a description of the recent work which has been done by Dr. Kemna at Antwerp on the biology of filtration.

The methods of water analysis described are, in general, in accord with those used in the best laboratories of the world. The judicial treatment of most of the subjects is to be commended. It might be asked by some why the author recommends the expensive tintometer for the determination of color, instead of the comparatively inexpensive platinum-cobalt solution of Hazen. Again, the author advises the expression of the degree of turbidity by the use of

adjectives, which of course mean nothing to an engineer. The Anthony turbidimeter¹ is described, to be sure, but it cannot be called "the most accurate yet devised," nor is the relation between its results and the amount of suspended matter contained in natural waters known.

The author advises the analyst to Nesslerize each portion of the ammonia distillate as it comes from the still. This method has long since been abandoned in this country, where the Nesslerized distillates are compared with Nesslerized standards, all under the same conditions of temperature, time, etc. The author is to be praised for including the new methods for determining the plumbo-solvency of waters. The description of the hardness method does not go into vagaries, and does not attempt to make results indicate more than is warranted, and the discussion of the methods for determining nitrogen as nitrates is the best we have seen. The methods given for the determination of poisonous metals, however, are rather crude, but so they are in all text-books. The bacteriological methods are carefully described.

While the book is especially adapted to English readers, it should have a wide circulation, as it is a fair, able and common-sense treatise on the subject.

¹ JOURNAL, N. E. W. W. ASSN., vol. 16, p. 256.

INDEX

TO THE

TRANSACTIONS

AND

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TO DECEMBER, 1903, INCLUSIVE.





NEW ENGLAND WATER WORKS ASSOCIATION.

ESTABLISHED 1882.

Index to the Transactions and Journal.

- Abbott, Dr Saml W.** Water a medium of contagion: remarks. 25, 26, V 2 No 4 June 88.
- Adams, Arthur L.** Stave pipe. Diags and ills. 247-287, disc 287, V 13 No 4 June 99.
- Advisability of the use of water meters.**
G. A. ROULLIER. 56-58, disc 59-65, V 5 No 1 Sept 90.
J. C. WHITNEY. 21, V 6 No 1 Sept 91.
- Aëration of water.**
BABCOCK, S. E. Aëration of water supplies by canals and low dams. 35-43, disc 43, 44, V 3 No 1 Sept 88.
BRUSH, C. B. Aëration and filtration of water. Ills. 71-77, disc 78-85, V 2 No 1 Sept 87.
DROWN, Prof T. M. Effect of aëration of natural waters. Tables and disc 96-102, V 7 No 2 Dec 92.
LEARNED, W. F. Aëration and oxidation of water. 43, 44, V 5 No 1 Sept 90.
- Air in pressure gages.** WINSLOW, G. E. 248, V 9 No 4 June 95.
- Air leaks in a tube well pumping plant (Cohasset).** TOWER, D. N. 189-193, disc 193, 194, V 12 No 3 Mar 98.
- Alarm valves for fire service.** CROSBY, E. U., and others. 111, 112, V 15 No 2 Dec 90.
- Albany, Ga.** CHASE, J. C. A cheap covered reservoir. 155, 156, V 8 No 3 Mar 94.
- Albany, N. Y.** HAZEN, A. Water filtration plant. 291-332, V 14 No 4 June 90.
- Algæ, etc, in water.** (See also Organisms.)
FORBES, F. F. Chara fragilis in reservoir. 252-254, V 10 No 4 June 96.
Algæ growth in reservoirs and ponds. 196-204, disc 204-210, V 4 No 4 June 90.
Taste and odor imparted to water by some algæ and infusoria. 90-96, disc 96, 97, V 6 No 2 Dec 91.
- HASKELL, J. C. Extermination of algæ by kerosene fire on pond bottom, Lynn, Mass. 64, V 10 No 1 Sept 95.

- HILL, W. R. Method of removing organisms from water in distributing reservoir of Syracuse, N Y. Ill. 213-216, disc 216-229, V 14 No 3 Mar 00.
- HOLLIS, F. S., and PARKER, H. N. Chlamydomonas in Spot pond, Middlesex Fells, Met Water Works. Diags. 26-29, disc 30. 31, V 14 No 1 Sept 99.
- Alger, Mayor Alphæus R.** Address to N E W W A, 14 Jan 91. 102, V 5 No 3 Mar 91.
- Allegheny river.** KNOWLES, MORRIS. Analyses of samples from Brilliant, Pittsburgh, Pa. 179-181, V 15 No 2 Dec 00.
- Allen, Charles A.** Novel way of placing a bridge in position (Worcester). 197, 198, V 3 No 4 June 89.
- Allis pumping engine.**
 REYNOLDS, I. H. 172-200, disc 200-205, V 13 No 3 Mar 99.
 DEAN, F. W. Triple expansion. Ills. 98, V 8 No 2 Dec 93.
- Allis, Solon M.**
 Breaking of pipes: experience, Malden, Mass. 274, V 11 No 3 Mar 97.
 Cement pipes: disc. 55, V 5 No 1 Sept 90.
 Economy in water-works management. 161-163, V 6 No 4 June 92.
 Erosion on the Pacific slope. 158-161, V 3 No 4 June 89.
 Experiences in the arid Southwest (Arizona). Map. 261-269, V 12 No 4 June 98.
 House inspection of fixtures: disc. 34-37, V 6 No 1 Sept 91.
 Malden, Mass. pipe system. 164-165, V 5 No 4 June 91.
 Relaying mains, Malden, Mass. 79; 80, V 5, No 2 Dec 90.
 Size of main pipes: disc. 18-25, V 5 No 1 Sept 90.
 Water supply sources: disc. 131-133, V 6 No 3 Mar 92.
- Altoona, Pa.** KNIGHT, C. W. Reservoirs and floodwater channel. 151-162, V 14 No 2 Dec 99.
- Plan of Kittanning point. 97, V 14 No 2 Dec 99.
- Alum.**
 HAZEN, ALLEN. An agent in removal of color from peaty water. 33, 34, V 12 No 1 Sept 97.
 SWARTS, G. T. Use in filtration. 6-9, V 13 No 1 Sept 98.
- Alum and iron salts as water sterilizers.** DROWN, Prof T. M. 98, V 5 No 2 Dec 90.
- Alumina, sulphate of, for purification of water supplies.** WESTON, E. B. 333-353, disc 354-362, V 14 No 4 June 00.
- American covered reservoirs.** COFFIN, F. C. 254-261, V 14 No 3 Mar 00.
- American Water Works Assn.**
 Presents gavel to N E W W A, 12 June 89. 6, V 4 No 1 Sept 89.
 Joint meeting with N E W W A, 21 Apr 85, Boston. Procs 170-225 trans 85.
- Anabæna in water.** WESTON, R. S., and others. 27, V 13 No 1 Sept 98.

Analysis of water.

- COLLINS, M. F. Bacterial efficiency of the Lawrence filter. 294, V 17 No 3 Sept 03.
- DROWN, Prof T. M. Analysis of water: chemical, microscopical, bacteriological. 79-91, V 4 No 2 Dec 89.
- Hardness of water: disc. 135, V 6 No 3 Mar 92.
- GOODNOUGH, X. H. Some results of systematic examination of public water supplies. 65-78, disc. 78-81, V 14 No 1 Sept 99.
- HAZEN, ALLEN. The physical properties of water. Ills. 21-27, disc 27-31, V 17 No 1 Mar 03.
- HOLLIS, F. S. Methods for the determination of color and the relation of the color to the character of the water. Diags. 94-111, disc 111-118, V 13 No 2 Dec 98.
- SEDGWICK, Prof W. T. Biological examination of water. 7-14, V 2 No 4 June 88.
- Organisms which cause unpleasant tastes and odors in water supplies. 54-64, V 14 No 1 Sept 99.
- Recent progress in biological water analysis. Diag. 50-55, disc 56-64, V 4 No 1 Sept 89.
- STEARNS, F. P. Bacteria, typhoid: remarks. 22-25, V 2 No 4 June 88.
- Chemical analysis of water. 16, 17, 26, V 2 No 3 Mar 88.
- Effect of storage on quality of water. 115-125, V 5 No 3 Mar 91.
- WESTON, R. S. Occurrence of cristatella in the storage reservoir at Henderson, N. C. Map and diags. 20-26, disc 27-29, V 13 No 1 Sept 98.
- WHIPPLE, G. C. Growth of organisms in Boston water pipes. Diags and tables. 1-17, disc 17-19, V 12 No 1 Sept 97.
- The microscopy of drinking water: reviewed by Prof W. T. SEDGWICK. 59-62, V 14 No 1 Sept 99.
- Raphidomonas (infusorian) in Lynn water. Ill and disc. 348-357, V 11 No 4 June 97.
- Temperature of surface waters and its effect on growth of micro-organisms. Diags. 202-216, disc 216-222, V 9 No 4 June 95.
- WHIPPLE, G. C., and JACKSON, D. D. Asterionella, its biology, chemistry, and effect on water supplies. Diags. 1-23, disc 23-25, V 14 No 1 Sept 99.
- WINSLOW, C.-E. A. 459-477, disc 477-482, V 15 No 6 Dec 01.

Anchor ice.

- COGGESHALL, R. C. P. Anchor ice. 265-275, disc 275-277, V 10 No 4 June 96.
- HALE, R. A. Experience with anchor ice, Lawrence, Mass. 275, V 10 No 4 June 96.
- RICHARDS, W. H. Experience in anchor ice, New London, Conn. 275, V 10 No 4 June 96.
- SEYMOUR, C. W. S. Anchor ice and a recording pressure gage: experience (Hingham, Mass). 223-225, V 9 No 4 June 95.

- SPARKS, H. T. Experience with anchor ice. 276, V 10 No 4 June 96.
Annual Conventions N E W W A. See N E W W A Meetings.
- Anthony, Charles, Jr.** Turbidimeter. Diag. 256-259, disc 259-262, V 16 No 4 Dec 02.
- Aqueducts.**
- DENTON, Prof J. E. Note of lecture on Croton aqueduct, N. Y. 12, 13, V 3 No 1 Sept 88.
- FITZGERALD, DESMOND. Description of Croton aqueduct, N. Y. 106-108, V 11 No 1 Sept 96.
 Visit to Croton aqueduct, N. Y. 161, 162, V 3 No 4 June 89.
- FTELEY, A. Note of address on Croton aqueduct, N. Y. 16, V 5 No 1 Sept 90.
- NOYES, A. F. Nashua-Sudbury: cross section diagrams. 127, V 10 No 2 Dec 95.
- Arid Southwest (Arizona).** ALLIS, S. M. Experiences in the. 261-269, V 12 No 4 June 98.
- Arizona.** ALLIS, S. M. Experiences in the arid Southwest: map. 261-269, V 12 No 4 June 98.
- Arnold, Col Olney.** Verses at Amer W W A & N E W W A dinner, 21 Apr 85 215-219, trans 85.
- Artesian well experiment at Taunton.** CHACE, G. F. 221-223, disc 223, 224, V 4 No 4 June 90.
- Ashland, Wis.** WHEELER, WILLIAM. Covered sand filter: diags and tables. 301-327, disc 327-329, V 11 No 4 June 97.
- Ashland basin, No 4, Boston.** LEARNED, W. F. Description, and mixing and handling concrete. Diags. 3-8, disc 8-11, V 2 No 2 Dec 87.
- Asiatic cholera.** SEDGWICK, Prof W. T. Epidemic from London water supply. 322-326, V 15 No 4 June 01.
- Assessment and collection of water rates: methods.** CRANDALL, F. H. 133-143, disc 143-150, V 14 No 2 Dec 99.
- Association of Engineers solicit co-operation of N E W W A.** Letter of JOHN C. TRAUTWINE, JR. 137-139, V 9 No 3 Mar 95.
- Asterionella.**
- FORBES, F. F. Effect on water. 92, 93, V 6 No 2 Dec 91.
 In Brookline and Waltham reservoirs. 25, 26, V 11 No 1 Sept 96.
- WHIPPLE, G. C., and JACKSON, D. D. Biology, chemistry and effect on water supplies. 1-23, disc 23-25, V 14 No 1 Sept 99.
 In deep and shallow ponds, distribution chart. 214, V 9 No 3 June 95.
- Astoria gravity stave pipe line.** ADAMS, A. L. Los Angeles Water Co. Ill. 253, V 13 No 4 June 99.
- Atkinson, Edward.**
- Fuel: what we don't know about it. 180-195, disc 195-200, V 17 No 2 June 03.
 Relation of water-works engineers to the fire service of factories. 58-63, disc 63-83, V 17 No 1 Mar 03.

Atlantic City, N J, Water Works Co. HAWLEY, W. C. Rotary and disc meter system results. Diags. 111-119, V 12 No 2 Dec 97.

Atlantic Highlands, N J. BASSETT, C. P. High and low service stand-pipe. Diags. 215-219, V 7 No 4 June 93.

Automatic sprinkler regulations. National Fire Protection Association. CROSBY, E. U. 103-109, V 15 No 2 Dec 00.

Ayres, John O. Portsmouth Water Works, N H. 67-69, disc 69, 70, V 13 No 1 Sept 98.

Babcock, Stephen E.

Aëration of water supplies by natural canals and low dams. 35-43, disc 43, 44, V 3 No 1 Sept 88.

Use of relief or safety valves in water-works distribution systems. 57-63, V 3 No 1 Sept 88.

Bachelder hydrant for Boston salt water fire system. MCINNES, F. A. Diags. 308-313, V 13 No 4 June 99.

Back filling trenches.

FULLER, F. L. 171-173, V 6 No 4 June 92.

GOWING, E. H. 173-177, disc 177, 188, V 12 No 3 Mar 98.

HAMMATT, E. A. W. 160-165, disc 166-172, V 12 No 3 Mar 98.

RICHARDS, W. H. 50, trans 84.

Bacteria.

DROWN, Prof T. M. Elimination by freezing. 46-52, V 8 No 1 Sept 93.

DUNHAM, Dr E. K. Statistics of bacteria in water about Boston, Mass. 14-19, V 2 No 4 June 88.

FITZGERALD, D. Typhoid. 19-21, disc 21, 22, V 2 No 4 June 88.

HASKELL, J. C. In surface waters of Mass. 80-84, V 13 No 2 Dec 98.

SEDGWICK, Prof W. T. Biological examination of water. 7-14, V 2 No 4 June 88.

SMITH, Dr T. Water borne diseases. 203-214, disc 214-225, V 10 No 4 June 96.

STEARNS, F. P. Typhoid. 22-25, V 2 No 4 June 88.

SWARTS, Dr G. T. Decrease with sedimentation. 13, 14, V 13 No 1 Sept 98.

Bacterial analysis of water. WHEELER, WILLIAM. From Ashland, Wis., covered sand filter: tables. 320-325, V 11 No 4 June 97.

Bacterial purification of sewage. KINNICUTT, L. P. Diags. 119-141, disc 142-147, V 15 No 2 Dec 00.

Bacteriological analysis of water.

DROWN, Prof T. M. 79-91, V 4 No 2 Dec 89.

WINSLOW, C.-E. A. Its interpretation. 459-477, disc 477-482, V 15 No 6 Dec 01.

Bacteriology. SEDGWICK, Prof W. T. Influence on the theory of filtration. 334, V 15 No 4 June 01.

Badges, N E W W A. *See* N E W W A, Committee on badges.

Baerman, P. H. Cast-iron pipe (Phila Engs Club 4 Mar 82). 159, trans 85.

Bailey, George I.

Albany N Y, filtration plant: disc. 329-332, V 14 No 4 June 00.

Care of fire hydrants in winter. Ills, tables. 116-123, V 14 No 2 Dec 99.

Effect of water meters on consumption in large cities: statistics. 351-359, V 15 No 4 June 01.

Baker, M. N. Uniformity in municipal water-works reports. 189-192, V 15 No 2 Dec 00.

Baldwin, Charles H. Meters as detectors of waste and leakage. 34, 35, trans 83.

Ball, Phinehas.

Furnishing water power for motors from municipal water supply: disc. 155, 156, V 6 No 4 June 92.

Laying pipe across Chicopee, Springfield, and Quinnipiac, New Haven. 136, V 5 No 3 Mar 91.

Meter rates: disc. 41-46, trans 83.

Rainfall: disc. 50, 51, V 1 No 1 Sept 86.

Sand blast, experience. 158, V 3 No 4 June 89.

Soils from which water supplies may be drawn by filter galleries or driven wells. 29-32, disc 33, 34, V 3 No 1 Sept 88.

Died 19 Dec 94. Obituary 189, V 9 No 3 Mar 95.

Bancroft, Lewis M.

Iron removal plant (Reading Mass). Diags and tables. 294-300, V 11 No 4 June 97.

Treasurer N E W W A. 293-295, V 15 No 3, Mar 01. *See* N E W W A, financial statements.

Bancroft, Hon W. A. Address to N E W W A, 14 Mar 94. 167-170, V 8 No 4 June 94.

Barbour, William S. Died 24 Feb 89. Obituary 143, V 3 No 3 Mar 89. Resolutions of N E W W A on death. 148, 149, V 3 No 4 June 89.

Barrus, George H.

Calorific determination of the value of fuel. Ills of apparatus. 48-51, disc 51-54, V 10 No 1 Sept 95.

Economy in pumping engines as based on latest accomplishments. 163-170, disc 170, 171, V 13 No 3 Mar 99.

Electrical power for pumping plant. 195-197, V 10 No 3 Mar 96.

Basin and well covering of Waltham Water Works. JOHNSON, F. P. Diags. 120-122, disc 123-129, V 8 No 3 Mar 94.

Bassett, Carroll P. High and low service standpipe, Atlantic Highlands, N J, Water Co. Diags. 215-219, V 7 No 4 June 93.

Batchelder, George E., Pres N E W W A.

Address 14 June 94. 6-8, V 9 No 1 Sept 94.

Died 12 Mar 99. Obituary 349, V 13 No 4 June 99.

Battles, James Monroe. Died 8 June 01. Obituary 455, 456, V 15 No 5 Sept 01.

Bayles, James C.

Filtration of water supplies. 41, 42, V 5 No 1 Sept 90.

Membership status changed: letter. 17, 18, V 5 No 1 Sept 90.

Beach, Rev. D. N. Water in some of its higher relations (geological and political). 133-142, V 3 No 3 Mar 89.

Beals, Joseph E.

Back filling trenches: experience. 181-183, V 12 No 3 Mar 98.

How we painted our reservoir or standpipe (Middleboro). 157-158, V 3 No 4 June 89.

Service pipes: disc. 23-25, V 6 No 1 Sept 91.

Sinking funds: experience. 107-109, V 12 No 2 Dec 97.

Bell and spigot cast-iron pipe: standard weights and pressures suggested by foundry committee. Table. 366, V 16 No 4 Dec 02.

Bell end of water pipe.

Should it be cast bell down: disc. 18-21, V 7 No 1 Sept 92.

BRACKETT, D. Pipe coating and casting. 79, V 8 No 2 Dec 93.

Belleville, Paris. SWAN, C. H. Covered reservoir. 52, V 3 No 1 Sept 88.

Bellows pumps described. 37, V 1 No 1 Sept 86.

Bells, Depth of. Disc. 94-105, trans 85.

HILL, W. R., and others: disc. 40, 41, V 13 No 1 Sept 98.

TIDD, M. M., and others: disc. 9-12, V 3 No 1 Sept 88.

Bench testing of meters. THOMSON, J. Diags. 77-108, V 10 No 2 Dec 95.

Benzenberg, G. H. Arrangement of hydrants and pipes for fire protection: disc. 155-159, V 7 No 3 Mar 93. See Freeman, J. R.

Berlin-Stralau Water Works. Sand filters. Plates I-VIII. 102-114, V 7 No 2 Dec 92.

Bessom, Mayor of Lynn. Addresses to N E W W A.

11 Mar 96, Boston. 291-293, V 10 No 4 June 96.

10 June 96. 99-101, V 11 No 1 Sept 96.

Best form of service box. HOLDEN, H. G. 41, V 1 No 1 Sept 86.

Betton, J. M. Comparison of compound and triple expansion engines for small water-works plant. Diags and ills. 218-228, V 13 No 3 Mar 99.

Bickford, Nathan B. Died 24 June 99. Obituary 200, V 15 No 2 Dec 00.

Billings, William R.

Arrangement of hydrants and pipes for fire protection: disc. 152-155, V 7 No 3 Mar 93. See Freeman, J. R.

Best method of testing water meters: disc. 93-94, V 2 No 1 Sept 87.

Charge for hydrant service: disc. 28-32, V 1 No 1 Sept 86.

Desirability of meters: disc. 59, V 5 No 1 Sept 90.

Direct pumping system (Taunton). 77, V 6 No 2 Dec 91.

Meters as detectors of leakage and waste. 34-42, trans 83.

- Necessity for tanks to supply w c's and hot-water boilers. 51-56, disc 56-69, trans 85.
- Ratio of pumping capacity to maximum consumption: disc. 104-108, V 3 No 3 Mar 89. *See* Sherman, W. B.
- Service Pipes (Taunton). 20, V 2 No 1 Sept 87.
- Taunton street main flushing. Diag. 85-87, trans 85.
- Uniformity in reports of public water works. 118-140, disc 141-147, trans 85.
- Water hammer: disc. 73, 74, V 1 No 1 Sept 86.
- Weight of pipe: disc. 39, 40, trans 85.
- Wiped and cup joints, comparative value: disc. 71, 72, V 1 No 1 Sept 86.
- Biological analysis of water.**
- DROWN, Prof T. M. 79-91, V 4 No 2 Dec 89.
- DUNHAM, Dr E. K. 14-19, V 2 No 4 June 88.
- FITZGERALD, D. 19-21, disc 21, 22, V 2 No 4 June 88.
- FORBES, F. F. 90-96, disc 96, 97, V 6 No 2 Dec 91.
- SEDGWICK, Prof W. T. 7-14, V 2 No 4 June 88.
- Organisms which cause unpleasant tastes and odors in water supplies. 54-64, V 14 No 1 Sept 99.
- Recent progress in. 50-55, disc 56-64, V 4 No 1 Sept 89.
- WHIPPLE, G. C. 1-17, disc 17-19, V 12 No 1 Sept 97.
- Biological study of chlamydomonas in Spot pond, Mass.** HOLLIS, F. S., and PARKER, H. N. Diags. 26-29, disc 30, 31, V 14 No 1 Sept 99.
- Biology and chemistry of asterionella, and its effect on water supplies.**
- WHIPPLE, G. C., and JACKSON, D. D. 1-23, disc 23-25, V 14 No 1 Sept 99.
- Blake pumping engine.** DEAN, F. W. Ills. 94, V 8 No 2 Dec 93.
- Block-tin service pipes.** WHITNEY, J. C. Pitting of. 87, 88, V 6 No 2 Dec 91.
- Blossoming in water.** HODGKINS, Mr. 219-220, V 14 No 3 Mar 00. *See* Hill, W. R.
- Blow-off branches.** Plate VII, 78, V 8 No 2 Dec 93.
- N E W W A, committee on cast-iron pipe: tables. 87-90, V 17 No 1 Mar 03.
- HOWLAND, A. H. Blow-offs: disc. 83, 84, trans 85.
- Blue prints and sketches.** *See* N E W W A, Committee on.
- Boilers.** Allis pumping engines. 193, 194, V 13 No 3 Mar 99. *See* Reynolds, I. H.
- Bolling, Charles E.** Richmond Water Works, Va. 39-43, disc 43, 44, V 4 No 1 Sept 89.
- Book notices.**
- BURR, W. H. Ancient and modern engineering and the Isthmian canal. 126, V 17 No 1 Mar 03.
- CHURCH, I. P. Diagrams of mean velocity of uniform motion of water in open channels based on formula of Ganguillet and Kutter. 248, V 16 No 3 Sept 02.

- COFFIN, F. C. Graphical solution of hydraulic problems. 403, V 16 No 4 Dec 02.
 Municipal year-book. 1902. 403, V 16 No 4 Dec 02.
 WHIPPLE, G. C. The microscopy of drinking water. Reviewed by Prof W. T. SEDGWICK. 59-62, V 14 No 1 Sept 99.
Booke, Mr. Meters: disc. 107, V 10 No 2 Dec 95.
Boothby, Hon Frederick E. Address to N E W W A, 18 Sept 01, Portland. 445-447, V 15 No 5 Sept 01.
Boston aqueduct, water log sect. 1836. Ill. 71, V 13 No 1 Sept 98.
Boston, City of.
 BRACKETT, D. Fire of 28 Nov 89. Water supply. Plan. 182-185, disc 186, 187, V 4 No 4 June 90.
 DEAN, F. W. Sewage pumping engine. Ill. 89, V 8 No 2 Dec 93.
 FITZGERALD, D. Maximum water supply from Sudbury and Cochituate in time of drought: report on. Diags and tables. 12-32, V 2 No 2 Dec 87.
 Rainfall 1818-1886. Tables. 29, 30, V 2 No 2 Dec 87.
 GOULD, J. A. Gas mains. Tables of weights. 110, V 16 No 2 June 02.
 LEARNED, W. F. City street main flushing: letter. 81-83, trans 85.
 MCINNES, F. A. Salt-water fire system. Diags. 304-313, V 13 No 4 June 99.
Boston Water Works. Colorimeter. Ill. 107, V 13 No 2 Dec 98.
 BRACKETT, D. Main cleaning in 1886-87. 341-344, V 13 No 4 June 99.
 WHIPPLE, G. C. Growth of organisms in pipes. Diags and tables. 1-17, disc 17-19, V 12 No 1 Sept 97.
Bowers, George.
 Result of experiments. 30-33, disc 33-35, V 13 No 1 Sept 98.
 Second tube well plant, Lowell, Mass. 226-229, V 10 No 4 June 96.
 Tube wells, Lowell, Mass: experiments. 67-76, V 9 No 2 Dec 94.
 Underground water: how to obtain and care for it. 127-132, disc 132-137, V 17 No 2 June 03.
Boyce, W. C.
 Tubular well tests, reliability questioned. 26-28, V 3 No 1 Sept 88.
 Died 15 July 89. Obituary 65, V 4 No 1 Sept 89.
Boyle, Mayor of Newport. Address to N E W W A, 8 Sept 97. 56, V 12 No 1 Sept 97.
Brackett, Dexter. Pres N E W W A.
 Address to N E W W A, 11 June 90. Portland, Me. 2-4, V 5 No 1 Sept 90.
 Arrangement of hydrants and pipes for fire protection. 77-79, V 7 No 1 Sept 92.
 Brass bushed pipes for driven wells. 142, V 5 No 3 Mar 91.
 Cambridge power station, electrolytic action near. 256, V 15 No 3 Mar 01.

- Capacity tests of steam fire engines, hydrants, and hose, with tables. 151-162, V 9 No 3 Mar 95.
- Cast-iron water pipes on Met Water Works. 325-332, V 13 No 4 June 99.
- Cleaning Boston Water Works mains, 1886-87. 341-344, V 13 No 4 June 99.
- Consumption of water, Europe and America. 122, 123, V 9 No 2 Dec 94.
- Excessive consumption of water. 233, 234, V 9 No 4 June 95.
- Furnishing motor power from municipal water supply: disc. 158, V 6 No 4 June 92.
- Laying pipe under or over a stream. 138, V 5 No 3 Mar 91.
- Lead connections in service pipes. 84, 85, V 6 No 2 Dec 91.
- Minimum size allowable for mains. 18-20, V 6 No 1 Sept 91.
- Pipe casting and coating. 13 tables of designs. 78-80, V 8 No 2 Dec 93.
- Pressure reducing valves. 144, 145, V 17 No 2 June 03.
- Raising or lowering of large water pipes. 198, 199, V 3 No 4 June 89.
- Ratio of pumping capacity to maximum consumption: disc. 109, 110, V 3 No 3 Mar 89. *See* Sherman, W. B.
- Reservoir embankment construction. 139, V 8 No 3 Mar 94.
- Scrapers for pipe cleaning. 4, V 1 No 3 Mar 87.
- Steel *v.* cast-iron pipes, and corrosion. 223-225, V 11 No 3 Mar 97.
- Water supply at Boston fire, 28 Nov 89. Plan. 182-185, disc 186, 187, V 4 No 4 June 90.
- Water waste: disc. 56, 57, V 1 No 1 Sept 86. Paper. 10-17, V 1 No 2 Dec 86.
- Brckett, Hon J. Q. A.** Address at Amer W W A and N E W W A dinner, 21 Apr 85. 206-209, trans 85.
- Brainard, C. M.** Died 25 Dec 93. Obituary 195, V 8 No 4 June 94.
- Branches, Pipe.** Diags and dimensions. Plates IV-VI. 78, V 8 No 2 Dec 93.
- N E W W A tables. 348-352, V 16 No 4 Dec 02.
- Brand, Junius A.** Lead joints: disc. 94-105, trans 85.
- Brass bushed pipes for driven wells.** BRACKETT, D. 142, V 5 No 3 Mar 91.
- Breaking of pipes: experience.**
- ALLIS, S. M. (Malden). 274, V 11 No 3 Mar 97.
- BROWN, J. H. 45, 46, trans 85.
- Breeches pipe, mould and core.** GARRETT, JESSE. Ill. 50, 51, 54, V 11 No 1 Sept 96.
- Bridge.** ALLEN, C. A. A novel way of placing a bridge in position (Worcester). 197, 198, V 3 No 4 June 89.
- Broad canal, Cambridge.** HARRINGTON, J. L. Laying of siphon under. 90-95, V 7 No 2 Dec 92.

- Broken mains.** STACY, G. A. Location and examination in cold weather. 222-224, V 7 No 4 June 93.
- Brookline Water Works, Mass.**
 COFFIN, F. C. Covered reservoir: description. 254, V 14 No 3 Mar 00.
 FORBES, F. F. Cement-lined pipe, a success. 44-48, disc 48-57, V 15 No 1 Sept 00.
 Covered reservoir. Diags. 113-117, V 8 No 3 Mar 94.
 Driven wells. 195-199, disc 199-201, V 11 No 3 Mar 97.
- Brooklyn Water Works, N Y.** WHIPPLE, G. C., and JACKSON, D. D. Asterionella. Diag of number per cc. 12, V 14 No 1 Sept 99.
- Brooks, Edwin C.** Pressure reducing valves. 143, 144, V 17 No 2 June 03.
- Brooks, Frederick.** Folly of reckoning by gallons, while all countries have identical liters and cubic meters. 258-267, V 17 No 3 Sept 03.
- Brown, A. W. F.** Card system of service locations. 226-228, V 9 No 4 June 95.
- Brown, J. Henry.**
 Breaking of cast-iron pipes. 45, 46, trans 85.
 Necessity and method of flushing street mains. Diag. 70, 71, disc 71-92, trans 85.
- Brownell, E. E.** Electrolysis of pipes from facts and figures. Ill. 363-367, disc 367-372, V 14 No 4 June 00.
- Brush, Charles B.**
 Aëration and filtration of water. 71-75, ills 76, 77, disc 78-85, V 2 No 1 Sept 87.
 Died 3 June 97. Obituary 72, V 12 No 1 Sept 97.
- Buffalo Water Works, N Y.**
 KNAPP, L. H. Description, Ill. 206-212, V 14 No 3 Mar 00.
 Cast-iron pipe specifications, 102, 103, V 16 No 2 June 02.
- Burlington, Vt, Water supply.**
 CRANDALL, F. H. Map and ills. 150-159, disc 159-166, V 10 No 3 Mar 96.
 PARKER, F. H. High-service motor. 63-66, disc 66-68, V 2 No 1 Sept 87.
 SEDGWICK, Prof W. T. Sanitary condition. 167-183, V 10 No 3 Mar 96.
- Bursting of Portland reservoir.** FREEMAN, J. R. Diag. 148-152, disc 152-154, V 8 No 3 Mar 94.
- By-pass metering devices.** Diags. 78, V 12 No 2 Dec 97.
- By-passes in meters.** CRANDALL, F. H. Experiments to determine amount of water used. Table and diag. 347, V 11 No 4 June 97.
- Cabinet presented to Mr and Mrs Hill.** N E W W A, Meetings, Annual. 191, 192, V 14 No 2 Dec 99.
- Calipering pipe.** SHERMAN, W. B. 35-37, trans 85.
- Calorific determination of the value of fuel.** BARRUS, G. H. Ills. 48-51, disc 51-54, V 10 No 1 Sept 95.

- Cambridge power station.** BRACKETT, DEXTER. Electrolytic action on 48-inch main. 256, V 15 No 3 Mar 01.
- Cambridge Water Works, Mass.** HASTINGS, L. M. Ills. and diags. 121-132, V 11 No 2 Dec 96.
- Campbell's cast-iron fire cistern.** BENZENBERG, G. H. Diag. 158, V 7 No 3 Mar 93.
- Canals and low dams.**
 BABCOCK, S. E. Aëration of water supply by. 35-43, disc 43, 44, V 3 No 1 Sept 88.
 LOCKE, A. W. Notes made in Holland in 1887. 44-49, V 5 No 1 Sept 90.
- Capacity tests of steam fire engines, etc.** BRACKETT, DEXTER. 151-162, V 9 No 3 Mar 95.
- Caps.** Diags and dimensions. Plate II, 78, V 8 No 2 Dec 93.
 N E W W A standard. Tables. 91-92, V 17 No 1 Mar 03.
- Card system of service locations.** BROWN, A. W. F. 226-228, V 9 No 4 June 95.
- Care of fire hydrants in winter.** BAILEY, G. I. 116-123, V 14 No 2 Dec 99.
- Care of water mains.** CHACE, G. F. 131-134, V 5 No 3 Mar 91.
- Cast-iron gas main.** BROWNELL, E. E. Electrolysis of. Ill. 366, V 14 No 4 June 00.
- Cast-iron pipe.**
 BRACKETT, DEXTER. Met Water Works. 325-332, V 13 No 4 June 99.
 BROWNELL, E. E. Electrolysis. Ill. 363-367, disc 367-372, V 14 No 4 June 00.
 COFFIN, F. C. Notes on. Ill. 38-42, disc 42, 43, V 15 No 1 Sept 00.
 CRAFTS, N. H. Size and thickness: abstract from Watertown report, with tables. 175-196, V 3 No 4 June 89.
 EVANS, G. E., and others. Versus steel pipe: disc. 219-223, V 11 No 3 Mar 97.
 GARRETT, JESSE. Making of. Ills. 27-54, disc 55-62, V 11 No 1 Sept 96.
 MANNING, G. E. Design of lead joints. 130-138, V 16 No 2 June 02.
 MURDOCK, WILLIAM. Wooden joints in water mains (St. John, N B). 34-37, V 15 No 1 Sept 00.
 N E W W A. Standard specifications, with tables of weights and dimensions. 335-358, V 16 No 4 Dec 02, and 84-96, V 17 No 1 Mar 03.
 N E W W A. Reports, etc, of Committee. See N E W W A, Committee on cast-iron pipe.
 NOYES, A. F. Weights of pipes: disc. 28-51, diags 154-159, trans 85.

- SAVILLE, C. M. Pipes and pipe laying, Met Water Works. 203-226.
disc 226-230, V 17 No 2 June 03.
- SHERMAN, W. B. Information wanted *in re.* 12-15, V 1 No 1 Sept 86.
91, 92, disc 92, 93, V 2 No 1 Sept 87.
- TAYLOR, L. A. Tapping band on. 229, 230, V 9 No 4 June 95.
- Casting water pipe bell end down.** Disc. 18-21, V 7 No 1 Sept 92.
- BRACKETT, DEXTER. Superiority. 78-80, V 8 No 2 Dec 93.
- Castings of pipes.**
- BRACKETT, DEXTER. Special designs. 78-80, V 8 No 2 Dec 93.
- HILL, W. R., and others. Cooling of. 37, V 13 No 1 Sept 98.
- N E W W A Com on, table and dimensions. 342, V 16 No 4 Dec 02.
- TIDD, M. M., and others. Use and weight: disc. 9-12, V 3 No 1
Sept 88.
- Cate, E. W.** Refusal of application for water and taxation of applicant:
disc. 32, 33, V 1 No 1 Sept 86.
- Caulking of joints.** HILL, W. R., and others: disc. 41-43, V 13, No 1
Sept 98.
- Causes and prevention of waste of water.** NEVONS, HIRAM, and others.
27-29, disc 30-47, trans 83.
- Causes of rainfall.** DAVIS, W. M. 338-345, disc by Prof W. H. Niles,
345-350, V 15 No 4 June 01.
- Cement-lined pipe.**
- CRILLY, P. F. Reasons for use. 50-52, disc 52-56, V 5 No 1 Sept 90.
- FORBES, F. F. Service pipes (Brookline). 44-48, disc 48-57, V 15
No 1 Sept 00.
- GOW, F. W. Cement-lined pipe: disc. 113-117, trans 85.
- HASKELL, J. C. Experience with. 171-173, disc 173-175, V 7 No 3
Mar 93.
- HAWKES, Mr. Cement-lined pipe, Malden. 40, trans 83.
- WINSLOW, G. E. Effect of water hammer on. 191-194, disc 194-
196, V 4 No 4 June 90.
- Cemeteries, proximity to water harmless.** SWARTS, Dr G. T. 10, V 13,
No 1, Sept 98.
- Chace, George F.,** Pres N E W W A.
- Address to N E W W A, twelfth annual convention. 3-5, V 8 No 1
Sept 93.
- Advisability of meters, and city ownership. 21, 22, V 6 No 1 Sept 91.
- Artesian well experiment (Taunton). 221-223, disc 223, 224, V 4
No 4 June 90.
- Care of water mains in relation to quality of supply. 131-134, V 5
No 3 Mar 91.
- Cement-lined service pipes (Taunton). 24, V 6 No 1 Sept 91.
- Corrosion of pipes, Taunton. 336, 337, V 15 No 4 June 01.
- Direct pumping system (Taunton). 67-75, disc 76-80, V 6 No 2 Dec 91.
- Eternal vigilance the price of good water. 147-150, V 9 No 3 Mar 95.
- Excessive consumption of water. 235-239, V 9 No 4 June 95.

- Experience with Crown water meter. 60, V 5 No 1 Sept 90.
 Friction in collecting meter rates. 44-50, V 4 No 1 Sept 89
 Handling fires while changing distribution mains on important streets
 (Taunton). 230-233, V 10 No 4 June 96.
 Laying a 16-inch main across a rocky mill stream and over a dam
 (Taunton). 103-105, disc 105, V 9 No 2 Dec 94.
 Rainfall of 1890-91. 138, V 6 No 3 Mar 92.
 Rumpus in collecting meter rates (Taunton). 230-237, disc 238, 239,
 V 14 No 3 Mar 00.
 Service pipes, defects and remedy. 41-45, disc 45-55, V 12 No 1
 Sept 97.
 Sixteen-inch direct river pipe and effect on Taunton supply. 179-181,
 V 6 No 4 June 92.
Chaffee, Fred I. Died 28 Nov 95. Obituary 140, V 10 No 2 Dec 95.
Chain of pots, water elevators. FANNING, J. T. 36, V 1 No 1 Sept 86.
Chandler, Henry. Died 19 Oct 00. Obituary 224, V 15 No 2 Dec 00.
Chaplin, W. S. Water in Japan. 20-26, V 1 No 2 Dec 86.
Chapman fourway independent valve hydrant. Springfield fire depart-
 ment. Hose experiments. 152, trans 85.
Chara fragilis. FORBES, F. F. Appearance in reservoir of public water
 supply. 252-254, V 10 No 4 June 96.
Charge for hydrant service. BILLINGS, W. R., and others. 28-32, V 1
 No 1 Sept 86.
Charges for private fire protection and means of controlling supply. Re-
 port of N E W W A Committee. 290-329, V 16 No 4 Dec 02.
Charges for public use of large streams. CRANDALL, F. H. Method of
 determining. 344-347, V 11, No 4 June 97.
Charlottetown, P. E. Isle, sewage pumping plant. COFFIN, F. C. 214,
 215, V 13 No 3 Mar 99.
Chase, John C.
 Charge for hydrant service: disc. 30, V 1 No 1 Sept 86.
 Cheap covered reservoir, Albany, Ga. 155, 156, V 8 No 3 Mar 94.
 Corrosion of pipes: disc. 46, trans 85.
 Disjointing 12-inch pipe. 102, 103, trans 85.
 Experience with a stand pipe. 68-70, V 8 No 2 Dec 93.
 Four-inch bells and lead joints. 99-100, trans 85.
 Function of a water meter. 102, V 10 No 2 Dec 95.
 House inspection of fixtures. 34-38, V 6 No 1 Sept 91.
 Little talk about water rates. 174-179, V 17 No 2 June 03.
 Necessity of tanks for kitchen boilers and water closets: disc. 60-62,
 trans 85.
 Weight of pipe: disc. 33, 34, trans 85.
Cheap water for the people. (Mass. laws *in re* pond water.) STETSON,
 T. M. 1-18, V 1 No 4 June 87.
Check valves and meters in factory fire systems. FRENCH, E. V., and
 others. 96-102, V 12 No 2 Dec 97.

Chemical analysis of water.

DROWN, Prof T. M. 79-91, V 4 No 2 Dec 89.

Odor and color of surface waters. 3-15, disc 15-29, V 2 No 3 Mar 88.

Chemical pump (Warren). Ills. WESTON, E. B. 341-344, V 14, No 4 June 00.

Chestnut Hill (Met Water Works) high service station. SANDO, W. J. Thirty-million gallon pumping engine trial. 232-243, V 15, No 3 Mar 01.

Chicopee, Springfield. BALL, PHINEHAS. Laying pipe across Chicopee and Quinipiac. 136, V 5 No 3 Mar 91.

Chlamydomonas in Spot pond (Met Water Works). HOLLIS, F. S., and PARKER, H. N. Diags. 26-29, disc 30, 31, V 14 No 1 Sept 99.

Chlorophyceæ: green algæ in surface water. WHIPPLE, G. C. 212, V 9 No 4 June 95.

Clark, Ezra.

Water hammer: disc. 76, V 1 No 1 Sept 86.

Died 26 Sept 96. Obituary 275, V 11 No 3 Mar 97.

Clark, Harry W.

Experience with filters (Lawrence). 231-234, 241-243, V 12 No 4 June 98.

Few words on water filtration. 82-87, V 14 No 1 Sept 99.

Pollution of streams by manufactural wastes, and prevention. 500-510, disc 510-513, V 15 No 6 Dec 01.

Removal of color, organisms, and odor from water. 1-8, V 17 No 1 Mar 03.

Removal of iron from ground waters by coke filters. 277-280, disc 280-284, V 11 No 4 June 97.

Clarke Ave station, Montreal Water Works. PITCHER, F. H. Pumping by electricity. 352-373, V 17 No 4 Dec 03.

Classification of water rates. See Water rates.

Cleaning pipes. NEVONS, HIRAM. 23, 24, V 5 No 1 Sept 90.

Cleaning reservoirs.

COGGESHALL, R. C. P. New Bedford. 210, 211, disc 211, 212, V 4 No 4 June 90.

HASKELL, J. C. 29, 30, V 12 No 1 Sept 97.

Cleaning water mains.

BRACKETT, DEXTER. Boston. 1886, 1887. 341-344, V 13 No 4 June 99.

MURDOCK, W. St. John, N B. Abstract from report. 147-151, V 13 No 2 Dec 98.

Paper. Ills. 333-341, disc 341-344, V 13 No 4 June 99.

Clinton gatehouse, E Jersey Water Co. HERSCHEL, CLEMENS. Diag. 26, V 8 No 1 Sept 93.

Coal. BARRUS, G. H. Calorific determination of value as fuel. Ill. 48-51, disc 51-54, V 10 No 1 Sept 95.

Coating of pipes.

BRACKETT, DEXTER. Met Water Works. 330, 331, V 13 No 4 June 99.

COFFIN, F. C., and others. Coating of pipes. 44-48, V 13 No 1 Sept 98.

GARRETT, JESSE. 52-54, disc 61-62, V 11 No 1 Sept 96.

HASTINGS, L. M. Protective coating for steel pipes. 321-323, V 13 No 4 June 99.

WALKER, C. K., and others. Use of water from hydrants. 143, V 10 No 3 Mar 96.

WOOD, EDMUND. Steel (New Bedford Water Works). 213, disc 220-225, V 11 No 3 Mar 97.

Cochituate and Sudbury watersheds. FITZGERALD, DESMOND. Capacity in drought. 12-21, diag and tables 22-32, V 2 No 2 Dec 87.

Cochran, Robert L., and others. Ice in standpipes. 227-229, V 17 No 2 June 03.

Cochrane, Hon James. Address of welcome to N E W W A, Montreal, 9 Sept 03. 420, V 17 No 4 Dec 03.

Cocks, Proper manufacture of. HILL, W. R. 37, 38, V 13 No 1 Sept 98.

Codd, William F.

Filter at Wannacomet Water Works, Nantucket. Diags. 171-174, V 8 No 4 June 94.

Method of connecting lead services. 187, 188, V 9 No 3 Mar 95.

Nantucket pumping engines, Wannacomet Water Works. 174-176, V 16 No 3 Sept 02.

Coffin, Freeman C.

Application of gas, gasoline, and oil engines to pumping machinery.

Diags. 206-217, V 13 No 3 Mar 99.

Coating of pipes: disc. 44-48, V 13 No 1 Sept 98.

Corrosion of pipes. 222, V 11 No 3 Mar 97.

Covered reservoir at Cohasset: experience. 127, V 8 No 3 Mar 94.

Covered reservoirs and their design. Diags. 252-285, V 14 No 3 Mar 00.

Few notes on cast-iron pipe. Ill. 38-42, disc 42, 43, V 15 No 1 Sept 00.

Financial management of water works: statistics and diags. 63-86, disc 87-98, V 11 No 1 Sept 96.

Friction in several pumping mains. Diags, tables, and disc. 234-242, V 10 No 4 June 96.

Lead connections in service pipes. 85, 86, V 6 No 2 Dec 91.

Pressure reducing valves. 142-145, V 17 No 2 June 03.

Standard flanges for water pipes. Diags and disc. 48-51, V 6 No 1 Sept 91.

Standpipe at Fairhaven. 181, V 8 No 4 June 94.

Standpipes and their design. Diags. 202-214, V 7 No 4 June 93.

Coggeshall, Robert C. P., Pres N E W W A. Portrait. 282, V 16 No 4 Dec 02.

- Address to N E W W A, 16 June 86. 5-9, V 1 No 1 Sept 86.
 Anchor ice. 265-275, disc 275-277, V 10 No 4 June 96.
 Fall of Fairhaven water tower. Ills. 522-524, V 15 No 6 Dec 01.
 Lead service pipes. 87, V 6 No 2 Dec 91.
 Meters in fire services: disc. 27-33, V 6 No 1 Sept 91.
 Method of cleaning distributing reservoir (New Bedford). 210, 211, disc 211, 212, V 4 No 4 June 90.
 Naphtha lamps for melting lead joints. 103, trans 85.
 Portable platform to aid in excavating trenches. 125, 126, V 9 No 2 Dec 94.
 Private fire supplies and insurance regulations. 193-197, V 9 No 4 June 95.
 Resignation of secretaryship N E W W A, 9 Jan 95, 141-144, V 9 No 3 Mar 95.
 Service pipes (New Bedford). 22-27, V 6 No 1 Sept 91.
 Stealing water and check valves. 68-72, V 17 No 1 Mar 03.
 Tanks for hot-water boilers, etc: disc. 57-59, trans 85.
 Temporary dam at New Bedford. 200, 201, V 3 No 4 June 89.
 Testing distributing mains. 337, 338, V 11 No 4 June 97.
 Twenty years after (inception of N E W W A), a retrospect. 271-289, portraits 276-284, V 16 No 4 Dec 02.
Cohasset Water Works, Mass.
 COFFIN, F. C. Covered reservoir: experience. 127, V 8 No 3 Mar 94.
 Oil pumping engine. 210-212, V 13 No 3 Mar 99.
 Kerosene oil pumping engine. Ill. 176, V 16 No 3 Sept 02.
 TOWER, D. N. Air leaks in a tube well pumping plant: experience. 189-193, disc 193, 194, V 12 No 3 Mar 98.
Coke filters for removal of iron from ground waters. CLARK, H. W. 277-280, disc 280-284, V 11 No 4 June 97.
Collins, M. F. The Lawrence filter. Diag and ill. 288-297, V 17 No 3 Sept 03.
Colon bacillus (cholera). WINSLOW, C.-E. A. Isolation of. 471-475. Significance. 475-477, V 15 No 6 Dec 00.
Color and odor of surface waters. DROWN, Prof T. M. 3-15, disc 15-29, V 2 No 3 Mar 88.
Color removal by filtration. HAZEN, ALLEN. 32-34, V 12 No 1 Sept 97.
Color in relation to character of water. HOLLIS, F. S. Diags. 94-111, disc 111-118, V 13 No 2 Dec 98.
Colorimeter. Boston Water Works. 102-111, diag 107, V 13 No 2 Dec 98.
Coloring matter in water and removal. FITZGERALD, D., and others. Disc 156-163, V 16 No 2 June 02.
Combustion engines. See Pumping engines.
Committees, N E W W A. See N E W W A, Committees.
Comparative value of wiped and cup joints. BILLINGS, W. R., and others. 71, 72, V 1 No 1 Sept 86.

- Comparison of compound and triple engines.** BETTON, J. M. 218-228, V 13 No 3 Mar 99.
- Comparison of pumping engines.** SMITH, J. E. 163-166, disc 166-170, V 14 No 2 Dec 99.
- Compound pipe.** HASTINGS, L. M. Flow of water in 36-inch and 30-inch compound pipe. Diags 189-194, V 8 No 4 June 94. Remarks of G. A. Ellis. 58, 80. Reply of L. M. Hastings. 61, 62, V 9 No 1 Sept 94.
- Compound pumping engines.** See Pumping engines.
- Conant, Henry W.**
Hydrants: disc. 12, 13, V 4 No 1 Sept 89.
Died 18 Nov 99. Obituary 193, V 14 No 2 Dec 99; 200, V 15 No 2 Dec 00.
- Concrete masonry in Forbes hill reservoir, Met Water Works.** SAVILLE, C. M. Ills. 191-204, V 16 No 3 Sept 02.
- Concrete mixing and handling in Ashland basin No 4 (Boston).** LEARNED, W. F. 7, 8, disc 8-11, V 2 No 2 Dec 87.
- Condensing apparatus.** Allis pumping engines. 191-193, V 13 No 3 Mar 99. See Reynolds, I. H.
- Conduits.**
DAVIS, W. E. Pipe removal in sections (Sherburne, N Y): experience. 125, 126, disc 127-129, V 5 No 3 Mar 91.
HERSCHEL, C. Structures, E Jersey Water Co. Diag. 30, V 8 No 1 Sept 93.
Structures and pipe line appurtenances, E Jersey Water Co. Diag. 32, 35, V 8 No 1 Sept 93.
E Jersey Water Co air valve details. Diag. 32, V 8 No 1 Sept 93.
KUCHLING, E. Gaging of (Rochester, N Y). 138-143, V 13 No 2 Dec 98.
RICHARDS, W. H. Accident on tile pipe conduit, New London, Conn. 164, V 3 No 4 June 89.
- Conflagration hazard.** CROSBY, E. U. Eliminating the. 97-109, disc 110-118, V 15 No 2 Dec 00.
- Connet, F. N.** Stacy service box. Ill. 308, 309, V 15 No 4 June 01.
- Constitution and by-laws of the N E W W A.** See N E W W A Constitution.
- Construction and maintenance of water works.** KINGSLEY, C. W. 127-133, V 3 No 3 Mar 89.
- Consumption of water in larger U S cities as affected by meters.**
BAILEY, G. I. 351-359, V 15 No 4 June 01.
COFFIN, F. C., and others. Per capita: disc. 87, V 11 No 1 Sept 96.
HASKELL, J. C. Reduction of. 231-233, disc 233-239, V 9 No 4 June 95.
SHERMAN, W. B. And pumping capacity of various cities, 1886: table. 35, V 2 No 3 Mar 88.

- Safe ratio of pumping capacity to maximum consumption. 90-98.
V 3 No 2 Dec 88.
- Disc. 104-119, V 3 No 3 Mar 89.
- Contagion.** ABBOTT, Dr S. W. Water as a medium of contagion. 25.
26, V 2 No 4 June 88.
- Contracts.** KUICHLING, E. Case of Moffett, etc, breaking of contract
for steel conduit. 144-146, V 13 No 2 Dec 98.
- Control and management of service pipes.** WALKER, C. K., and others.
19-22, V 2 No 1 Sept 87.
- Control of hydrants by firemen.** HASKELL, J. C. 144, V 10 No 3
Mar 96.
- Control of watershed areas.** LATHAM, B. 129-131, V 13 No 2 Dec 98.
- Cook, Byron I., Pres N E W W A.**
Address to N E W W A, 19 Sept 00, Rutland. 193-199, V 15 No 2
Dec 00.
Detecting a waste of water. 22-24, V 7 No 1 Sept 92.
Service boxes: disc. Diags and ills. 305-314, V 15 No 4 June 01.
Standpipes, Woonsocket, R I. 124-127, disc 127-132, V 14 No 2
Dec 99.
Woonsocket Water Works, R I. Reservoir and dam No 3. Diags.
20-26, disc 27-35, V 12 No 1 Sept 97.
- Coolidge, Samuel S.** Died 9 Mar 89. Obituary 209, V 3 No 4 June 89.
- Co-operation.**
TRAUTWINE, J. C., Jr. Letter soliciting co-operation with association
of engineering societies. 137-139, V 9 No 3 Mar 95.
TRYON, JAMES. What a water supply engineer can do in the fire
department. 93-102, V 9 No 2 Dec 94.
- Cornell university, Ithaca.** FUERTES, Prof E. A. Hydraulic laboratory.
Ills. 195-205, V 14 No 3 Mar 00.
- Corrosion of pipes.** By sediment or tuberculation: disc. 105-107, V
8 No 2 Dec 93.
BRACKETT, D. Protection against corrosion in steel pipes. 325-331,
V 13 No 4 June 99.
CHASE, G. F. Taunton pipes, 1894. 337, V 15 No 4 June 01.
CHASE, J. C. Corrosion. 46, trans 85.
COFFIN, F. C., and others. Disc. 222-225, V 11 No 3 Mar 97.
PARKER, F. H. Corrosion. 41, trans 85.
WESTON, E. B., and others. Separate fire service systems: disc. 92,
V 13 No 2 Dec 98.
- Coryell, Martin.** Died 30 Nov 86. Obituary 101, V 2 No 1 Sept 87.
- Cost of operating sand filters.** HASKELL, J. C. 238, 239, 241, V 12 No
4 June 98.
- Cotton, J. Warren.** Died 30 July 84. Obituary 83, trans 84.
- Covered filter, Warsaw, Russia.** SEDGWICK, Prof W. T. In his purifi-
cation of water. 115, V 7 No 2 Dec 92.
- Covered reservoirs.** See also Reservoirs.

- COFFIN, F. C. Covered reservoirs and their design. 252-285, V 14 No 3 Mar 00.
- FORBES, F. F. Covered reservoir at Brookline. 113-117, V 8 No 3 Mar 94.
- FULLER, F. L. At Franklin, N H. 160, 161, disc 161, 162, V 5 No 4 June 91; 84, 85, V 7 No 1 Sept 92.
At Methuen, Mass. 123, V 8 No 3 Mar 94.
At Natick, Mass. 383-397, disc 398-417, V 17 No 4 Dec 03.
- SWAN, C. H. Covered reservoirs. 45-53, disc 53-56, V 3 No 1 Sept 88.
- Covered sand filter at Ashland, Wis.** WHEELER, WILLIAM. Diags and tables. 301-327, disc 327-329, V 11 No 4 June 97.
- Covered well and basin in Waltham Water Works, Mass.** JOHNSON, F. P. Diags. 120-122, disc 123-129, V 8 No 3 Mar 94.
- Covington reservoir water.** FITZGERALD, D. 77, V 5 No 2 Dec 90.
- Crafts, N. Henry.** Abstract from report to Watertown on cast-iron pipe. Table. 175-196, V 3 No 4 June 89.
- Crandall, F. H., Pres N E W W A.**
Address to N E W W A, 8 Jan 02. 66-69, V 16 No 1 Mar 02.
Assessment and collection of water rates. 133-143, disc 143-150, V 14 No 2 Dec 99.
Burlington, Vt, water system. Map and ills. 150-159, disc 159-166, V 10 No 3 Mar 96.
Inexpensive method of determining charges for public use of large streams. 344-347, V 11 No 4 June 97.
Laying 24-inch pipe under Lake Champlain, 1894. 259, 260, V 12 No 4 June 98.
Loss of water from underground pipes. 245-249, disc 249-253, V 12 No 4 June 98.
Private fire supply charges and control of service: disc. 416-420, V 15 No 5 Sept 01.
Testing water meters. 331, 332, V 17 No 4 Dec 03.
- Crehore, Dr Charles F.** Died 7 Nov 93. Obituary 108 V 8 No 2 D 93
- Crilly, Patrick F.**
Why I favor use of cement pipe. 50-52, disc 52-56, V 5 No 1 Sept 00.
Died 25 Mar 01. Obituary 364, 365, V 15 No 4 June 01.
- Cristatella in storage reservoir, Henderson, N C.** WESTON, R. S. Map and diag. 20-26, disc 27-29, V 13 No 1 Sept 98.
- Crosby, Everett U.** Eliminating the conflagration hazard. 97-109, disc 110-118, V 15 No 2 Dec 00.
- Croton aqueduct, N Y.**
DENTON, Prof J. E. Note of lecture by. 12, 13, V 3 No 1 Sept 88.
FITZGERALD, D. Description. 106-108, V 11, No 1 Sept 96.
Visit to. 161, 162, V 3 No 4 June 89.
FTELEY, A. Note of address by. 16, V 5 No 1 Sept 90.
- Croton water, N Y, before and after treatment by ozone: analysis.** SOPER, Dr. G. A., and others. 16, V 15 No 1 Sept 00.

Crown water meter. CHACE, G. F. 60, V 5 No 1 Sept 90.

Cup joints. ROGERS, H. W. 72, V 1 No 1 Sept 86.

Curved pipe.

BRACKETT, D. Pipe casting and coating, Diag. 78, V 8 No 2 Dec 93.

HASTINGS, L. M. Curved 40-inch steel pipe, Payson Park reservoir, Cambridge. 131, V 11 No 2 Dec 96.

Curved steel pipe, Cambridge. Ill. 316, V 13 No 4 June 99.

N E W W A, standards for cast-iron pipe. Table. 345-347, V 16 No 4 Dec 02.

WILLIAMS, Prof G. S. Loss of lead in. Experiments by Bossut, Du-Buat, Freeman, Rennie, Venturi, Weisbach, and Young. 112-114, V 14 No 2 Dec 99.

Resistance of curves. 100, 101, 112-115, V 14 No 2 Dec 99.

Cyanophyceæ: blue-green algæ in surface water. WHIPPLE, G. C. 212, V 9 No 4 June 95.

Cypress stave 24-inch pipe, New London, Conn. RICHARDS, W. H. 287, V 13 No 4 June 99.

Damages to mill powers. RAYMOND, W. G. 152-156, V 13 No 2 Dec 98.

Dams.

COGGESHALL, R. C. P. New Bedford temporary dam. 200, 201, V 3 No 4 June 89.

COOK, B. I. Woonsocket, R I, reservoir and dam. 20-27, disc 27-35, V 12 No 1 Sept 97.

FUERTES, Prof E. A., Cornell university, N Y. Old and new dams. Ills. 200, V 14 No 3 Mar 00.

HASKELL, J. C. Lynn Water Works, Mass. 55-63, disc 63, 64, V 10 No 1 Sept 95.

HASSAM, W. E. Worcester, Mass, distributing reservoir. 153-159, V 12 No 3 Mar 98.

HASTINGS, L. M. Cambridge Water Works, Hobbs Brook. Diags and ill. 123, 124, V 11 No 2 Dec 96.

HERSCHEL, CLEMENS. Macopin intake, E Jersey Water Co, Newark. 21, 22, V 8 No 1 Sept 93.

HOLDEN, H. G. Pennichuck Brook, Nashua, N H. Ill. 250-252, V 16 No 4 Dec 02.

HOWARD, J. L. Middlesex Fells reservoir plans (Met Water Works, Mass). 22. Ills. 28-30, V 15 No 1 Sept 00.

KNIGHT, C. W. Altoona, Pa, lower reservoir and dam. Ill and diag. 158, 159, V 14 No 2 Dec 99.

LEARNED, W. F. Ashland basin No 4, Boston. Diags. 4-7, V 2 No 2 Dec 87.

METCALF, LEONARD. Echo Lake dam, Milford, Mass. 146-156, V 17, No 2 June 03.

NOYES, A. F. Comparative sections of masonry. Diags. 124, V 10 No 2 Dec 95.

- STACY, G. A. Millham dam, Marlboro Water Works, Mass. Ill. 130-150. V 16 No 2 June 02.
- TAYLOR, L. A. New Haven Water Co, Woodbridge, Conn. 51-55. disc 55, 56, V 6 No 1 Sept 91.
- Newport Water Works, N H. 145, 146, V 12 No 3 Mar 98.
- Quincy dam, Mass. Diags. 167-173, disc 173, 174. V 3 No 4 June 89.
- Darling, Edwin, Pres N E W W A.**
- Address to N E W W A. 13 June 88. 2, 3, V 3 No 1 Sept 88.
- Charge for hydrant service: disc. 30-32, V 1 No 1 Sept 86.
- Durability of pipes: disc. Trans 85.
- Electrical purification of water supply. 188, V 8 No 4 June 94.
- Filtration. 165, 166, V 3 No 4 June 89.
- Frozen hydrants. 37, 38, V 4 No 1 Sept 89.
- Necessity for large-sized pipes: disc. 180, V 4 No 4 June 90.
- Practical details of water-works management. 7-11, disc 11-18, V 2 No 1 Sept 87.
- Public and private water works: disc. 17-24, V 4 No 1 Sept 89.
- Reservoir embankment construction: disc. 141, V 8 No 3 Mar 94.
- Service pipes: disc. 20-22, V 2 No 1 Sept 87.
- Testing of pipes by manufacturers. 37, 38, trans 85.
- Water hammer: disc. 77, V 1 No 1 Sept 86.
- Weights of cast-iron pipes: disc. 31, 32, trans 85.
- Davidson, James.** Died 4 Dec 91. Obituary 188, V 6 No 4 June 92.
- Davis, F. A. W.**
- Electrical current. Ill. 225-232, V 15 No 3 Mar 01.
- Test of lifting water from wells with air, Indianapolis Water Works, Ind. 51-54, V 13 No 1 Sept 98.
- Davis, W. E.** Removing conduit pipe in sections. 125, 126, disc 127-129, V 5 No 3 Mar 91.
- Davis, Prof W. M.** Causes of rainfall. 338-345, disc 345-350, V 15 No 4 June 01.
- Dayton, Ohio, Water Works.** BROWNELL, E. E. Electrolytic destruction of water mains. Ill. 370, V 14 No 4 June 00.
- Suit for damages for: decision. 151-155, V 16 No 3 Sept 02.
- Dead ends, Flushing of.** CHACE, G. F. 133, 134, V 5 No 3 Mar 91.
- Dean, Francis W.**
- Boilers: disc. 170, 171, 200-202, V 13 No 3 Mar 99. See Reynolds, I. H.
- Electrical power for pumping plants. 197-201, V 10 No 3 Mar 96.
- Groined arches. 414-417, V 17 No 4 Dec 03.
- High-grade pumping engines: disc. 184-186, V 9 No 3 Mar 95.
- Pumping engines: disc. 234, 235, V 11 No 3 Mar 97. See Loretz, A. J. L.
- Recent practice in pumping engines. Ills. 85-104, V 8 No 2 Dec 93.

- Recent specifications for pumping engines for St Louis Water Works. Mo: disc. 172-194, V 11 No 2 Dec 96.
- Dean and Main. Test of new pumping engine (Waltham, Mass). 171-173, V 14 No 2 Dec 99.
- Decker, John H.
Water pipe trenches. 77, V 8 No 2 Dec 93.
Died 8 May 01. Obituary 455, V 15 No 5 Sept 01.
- Defects in service pipes and remedy. CHACE, G. F. 41-45, disc 45-55, V 12 No 1 Sept 97.
- Dennett, Nathaniel. Died 21 Feb 00. Obituary 375, V 14 No 4 June 00: 200, V 15 No 2 Dec 00.
- Denton, Prof J. E. Note of lecture on Croton aqueduct, N Y. 12, 13, V 3 No 1 Sept 88.
- Depth of lead in pipe joints. HANCOCK, J. C., and others. 25, 26, V 5 No 1 Sept 90.
- Description of well to supply Waltham. FULLER, F. L. 183, 184, V 6 No 4 June 92.
- Detecting a waste of water. COOK, B. I. 22-24, V 7 No 1 Sept 92.
- Diaphanometers. WESTON, R. S. Turbidity determinations in New Orleans. 27-31, V 17 No 1 Mar 03.
- Diatomaceæ in surface water. WHIPPLE, G. C. 212-215, V 9 No 4 June 95.
- Diatoms.
WHIPPLE, G. C. Relation of light to growth of. Diags and tables. 1-24, disc 25, 26, V 11 No 1 Sept 96.
WHIPPLE, G. C., and JACKSON, D. D. Asterionella, effect on water supplies. Diags. 1-23, disc 23-25, V 14 No 1 Sept 99.
- Diesel motor (petroleum engine). COFFIN, F. C. 216, 217, V 13 No 3 Mar 97.
N E W W A Committee. Preliminary Table. 96, V 16 No 2 June 02.
- Dimensions of cast-iron pipes and special castings. N E W W A standards. Tables. 342-358, V 16 No 4 Dec 02, and 85-96, V 17 No 1 Mar 03.
- Direct pumping system (Taunton, Mass). CHACE, G. F. 67-75, disc 76-80, V 6 No 2 Dec 91.
- Direct river pipe and its effect on Taunton water supply. CHACE, G. F. 179-181, V 6 No 4 June 92.
- Disc meters. NOYES, A. F. 103, 104, V 10 No 2 Dec 95.
- Disc meters better than rotary. Atlantic City Water Works, N J. 118, 119, V 12 No 2 Dec 97.
- Discharge diagrams, E Jersey Water Co, Macopin intake gate-house. Diag. 40, V 8 No 1 Sept 93.
- Discharge of water from and through pipes: formulæ. 26, 27, V 1 No 2 Dec 86.
- Discharge of water mains. ELLIS, G. A. 19-26, V 1 No 1 Sept 86.

Disease and drinking water.

MASON, W. P. 139-144, V 6 No 3 Mar 92.

SEDGWICK, Prof W. T. Disease caused by pollution of water. 245-255, disc 255-265, V 11 No 3 Mar 97.

Water as a vehicle of disease (sanitation, nineteenth century). 315-337, V 15 No 4 June 01.

SMITH, Dr T. Water borne diseases (cholera, typhoid, malaria). 203-214, disc 214-225, V 10 No 4 June 96.

Distributing reservoirs. *See* Reservoirs.

Distribution statistics of water works.

N E W W A distribution statistics. Tables, main and service pipes.

See Statistics of water works.

Distribution systems of water works.

FULLER, F. L. Testing water pipes in. Ills. 330-335, disc 335-338, V 11 No 4 June 97.

HILL, W. R. Things to be done in construction. 36-39, disc 40-48, V 13 No 1 Sept 98.

WILLIAMS, G. S. Design for. 97-101, disc 101-115, V 14 No 2 Dec 99.

Division of water from streams.

HASTINGS, L. M. Method of estimating loss of water power from. 187-194, disc, diags and tables, 195-201, V 7 No 4 June 93.

MAIN, C. T. 199-201, V 7 No 4 June 93.

Dixon, William. Died 12 Sept 93. Obituary 108, V 8 No 2 Dec 93.

Doane, A. O. Driven wells. 133, 134, V 17 No 2 June 03.

Doherty, Cornelius F. Died 17 Nov 95. Obituary 140, V 10 No 2 Dec 95.

Downey, William. Died 1 Oct 01. Obituary 247, V 16 No 3 Sept 02.

Drainage of swamps for watershed improvement. LARNED, E. S. Ills. 36-44, disc 44-50, V 16 No 1 Mar 02.

Drinking fountains (Quincy, Mass). Speech of Dr FAXON. 111-114, V 5 No 3 Mar 91.

Drinking water and disease. *See* Disease and drinking water.

Drinking water from surface water supply. HASKELL, J. C. 137-155, V 11 No 2 Dec 96.

Drinking water, Purification of. SEDGWICK, Prof W. T. 103-130, V 7 No 2 Dec 92.

Driven wells. *See* Wells, Driven.

Drown, Prof Thomas M.

Algæ in ponds and reservoirs: disc. 204, V 4 No 4 June 90.

Biological analysis of water: disc. 56-58, V 4 No 1 Sept 89.

Chemical, microscopical, and bacteriological analysis of water. 79-91, V 4 No 2 Dec 89.

Covered reservoirs: disc. 53-56, V 3 No 1 Sept 88.

Effect of aëration of natural waters. Tables and disc. 96-102, V 7 No 2 Dec 92.

Electrical purification of water. 183-186, disc 186-188, V 8 No 4 June 94.

- Filtration of natural waters. 91-99, V 5 No 2 Dec 90.
- Filtration: Virchow and Devonshire processes. 81, 82, V 5 No 2 Dec 90.
- Hardness of water. 135, V 6 No 3 Mar 92.
- Odor and color of surface waters (chemical aspect). 3-15, disc 15-29, V 2 No 3 Mar 88.
- Purification of water by freezing. Tables. 46-52, V 8 No 1 Sept 93.
- Water supply sources. 130, 131, V 6 No 3 Mar 92.
- Dunham, Dr E. K.** Statistics of bacteria in water about Boston. 14-19, V 2 No 4 June 88.
- Durability of pipe.** DARLING, EDWIN. 43, trans 85.
- Duties of municipalities regarding water supply.** HALL, Hon J. O. 9-20, V 17 No 1 Mar 93.
- Dwight, Mayor Henry C.** Address to N E W W A. 10 June 91, Hartford, Conn. 1-4, V 6 No 1 Sept 91.
- Dwight Printing Co, Ashland.** Diagram of development of steam and water power before and after diversion from pond. 198, table 200, V 7 No 4 June 93.
- Dyer, Charles R.** Died 12 Sept 93. Obituary 195, V 8 No 4 June 94.
- East Providence, R I, filter plant.** WESTON, E. B. Ill. 345-347, V 14 No 4 June 00.
- Eaton, Horace L.** Died 23 Nov 95. Obituary 139, V 10 No 2 Dec 95.
- Echo Lake dam, Milford, Mass.** METCALF, L. 146-156, V 17 No 2 June 03.
- Economy in pumping engines as based on latest accomplishments.** BARBUS, G. H. 163-170, disc 170, 171, V 13 No 3 Mar 99.
- Economy in the use of coal for the production of power.** HOLLIS, I. N. 32-40, disc 40-43, V 17 No 1 Mar 03.
- Economy in water-works management.** ALLIS, S. M. 161-163, V 6 No 4 June 92.
- Eels in water works and their control.** FIELD, Dr G. W. Ills. 390-397, disc 398-405, V 15 No 5 Sept 01.
- Effect of meters on water consumption.** BAILEY, G. I. 351-359, V 15 No 4 June 01.
- Egglee, Charles H.**
Experience in back-filling trenches. 186, 187, V 12 No 3 Mar 98.
Setting hydrants, Rochester N Y. 12, V 4 No 1 Sept 89.
- Electrical current.** DAVIS, F. A. W. 225-231, V 15 No 3 Mar 01.
- Electrical power for pumping plant.** BARRUS, G. H. 195-197, V 10 No 3 Mar 96.
- Electrical pumping plant.** HAGUE, C. A. 184-195, disc 195-202, V 10 No 3 Mar 96.
- Electrical pumps.** PITCHER, F. H. 349-373, V 17 No 4 Dec 03
- Electrical purification of water.** DROWN, Prof T. M. 183-186, disc 186-188, V 8 No 4 June 94.

Electrolysis of pipes.

BROWNELL, E. E. From facts and figures. Ills. 363-367, disc 367-372, V 14 No 4 June 00.

DAVIS, F. A. W. 225-231, V 15 No 3 Mar 01.

Dayton, Ohio, Water Works. Electrolytic destruction. 370, V 14 No 4 June 00.

Suit for damage and decision. 151-155, V 16 No 3 Sept 02.

HASKELL, J. C. Lynn service pipes. 278-281, disc 281-286, V 10 No 4 June 96.

KNUDSON, A. A. Cause and effect on underground pipes. 244-255, disc 255-271, V 15 No 3 Mar 01.

Manufacturers Nat Gas Co. Case *v* Indianapolis Street R R Co for damages. 229-232, V 15 No 2 Dec 00.

MORSE, C. H. 139-145, disc 145-147, V 7 No 3 Mar 93.

STONE, C. A., and FORBES, H. C. 25-36, disc 36-43, V 9 No 1 Sept 94.

STORRS, Prof H. A. Diags. 33-42, disc 42-47, V 10 No 1 Sept 95.

WELLS, G. L. Absence in improved Wyckoff pipe. 301, V 13 No 4 June 99.

Elevators and motors. TUBBS, J. N. Reasons why power should not be furnished from municipal water works. 152-155, disc 155-160, V 6 No 4 June 92.

Eliminating the conflagration hazard. CROSBY, E. U. 97-109, disc 110-118, V 15 No 2 Dec 00.

Ellis, George A., Pres N E W W A. Portrait. 280, V 16 No 4 Dec 02.

Address at special meeting N E W W A, 29 Jan 85, Boston. 162-164, trans 85.

Address at Amer W W and N E W W A dinner, 21 Apr 85. 185-188, trans 85.

Address to N E W W A, 18 June 85, Springfield. 17-21, trans 85.

Discharge of water mains as determined by pressure gages. Diags. 19-26, V 1 No 1 Sept 86.

Two methods of obtaining fire protection. 27-31, V 7 No 1 Sept 92.

Water waste and leakage. 38-40, trans 83.

Embankments of reservoirs. TAYLOR, L. A. Construction. Diags. 130-133, disc 134-147, V 8 No 3 Mar 94.

Engineers suppression policy. SHERMAN, W. B. 28-30, trans 84.

Engines. MILLER, E. F. Waste heat engines. 44-50, disc 50, 51, V 17 No 1 Mar 03.

English covered reservoirs. COFFIN, F. C. 252, 253, V 14 No 3 Mar 00.

English filter beds. LEEDS, Dr A. R. 83, 84, V 2 No 1 Sept 87.

Epidemics and water supply. SEDGWICK, Prof W. T. 315-337, V 15 No 4 June 01.

Erosion and its effect on the Pacific slope. ALLIS, S. M. 158-161, V 3 No 4 June 89.

Eternal vigilance the price of good water. CHACE, G. F. 147-150, V 9 No 3 Mar 95.

European water supplies.

HAZEN, A. 109-121, disc 122-124, V 9 No 2 Dec 94.

LINDLEY, W. H. Report to Paris Exposition. 33-39, disc 39-44, V 5 No 1 Sept 90.

Evans, George E.

Manchester, N H, high service. Ills and diags. 68-75, V 10 No 1 Sept 95. See Rice, G. S., and Evans, G. E.

Steel pipe v cast-iron: disc. 219, 223, V 11 No 3 Mar 97.

Everett works of the New England Gas and Coke Co: description. 93-96, V 14 No 1 Sept 99.

Excavating in quicksand. NOYES, A. F. Experience. 218, 219, disc 219, 220, V 4 No 4 June 90.

Excessive consumption of water. HASKELL, J. C. 231-233, disc 233-239, Vol 9 No 4 June 95.

Exhibits. See N E W W A, Exhibits.

Experience with a sand blast. BALL, PHINEHAS. 158, V 3 No 4 June 89.

Experience with a stand pipe. CHASE, J. C. 68-70, V 8 No 2 Dec 93.

Experience with water hammer. FARNHAM, E. E. 56-59, V 6 No 1 Sept 91.

Experiences in the arid Southwest. ALLIS, S. M. 261-269, V 12 No 4 June 98.

Factory fire supplies. FRENCH, E. V. Meters in fire supplies cause loss of pressure. 73-94, disc 95-102, V 12 No 2 Dec 97.

Fairhaven Water Works, Mass.

COGGESHALL, R. C. P. Fall of water tower. Ills. 522-524, V 15 No 6 Dec 01.

NYE, J. K. 175-180, disc 180-182, V 8 No 4 June 94.

Fales, Frank L. Tonawanda Water Works, N Y. 23, V 4 No 1 Sept 89.

Fall River, Mass, water tank. KIERAN, PATRICK. Diag. 26-32, V 2 No 1 Sept 87.

Fanning, J. T.

Arrangement of hydrants and pipes for fire protection: disc. 79-81, V 7 No 1 Sept 92.

Types of hydraulic pumping machinery. Ills. 34-41, V 1 No 1 Sept 86.

Farnham, E. E.

Electrolysis of water pipes: disc. 36-38, V 9 No 1 Sept 94.

Experience with water hammer (Sharon, Mass). 56, 57, disc 57-59, V 6 No 1 Sept 91.

Faxon, Dr (Quincy, Mass). Drinking fountains: speech. 111-114, V 5 No 3 Mar 91.

Field, Dr George W. Eels in water works and their control. Ills. 390-397, disc 398-405, V 15 No 5 Sept 01.

Filter galleries on borders of rocky ponds, practicability of.

TIDD, M. M. 106-108, V 5 No 3 Mar 91.

BALL, PHINEHAS. Use in various soils. 29-32, disc 33, 34, V 3 No 1 Sept 88.

Filter plants and filters.

BALL, PHINEHAS. Soils from which water may be drawn by filter galleries or driven wells. 29-32, disc 33, 34, V 3 No 1 Sept 88.

CLARK, H. W. Experience with filters in Lawrence, Mass. 231-234; 241-243, V 12 No 4 June 98.

Removal of color, organisms, and odor from water. 1-8, V 17 No 1 Mar 03.

CODD, W. F. Wannacomet Water Works, Nantucket. Diag. 171-174, V 8 No 4 June 94.

COLLINS, M. F. The Lawrence filter. 288-297, V 17 No 3 Sept 03.

FOWLER, C. E. Slow sand filter at Poughkeepsie, N Y. 209-227, disc 227-244, V 12 No 4 June 98.

FULLER, G. W. Relative applicability of sand and mechanical filters. 32-43, disc 43-53, V 14 No 1 Sept 99.

HAZEN, ALLEN. Albany, N Y. Diag and ills. 291-332, V 14 No 4 June 00.

Selection of sands for. 165-168, V 7 No 3 Mar 93.

HOLLIS, F. S., and others. Coke for removal of color from water: disc. 116-118, V 13 No 2 Dec 98; 158, 159, V 16 No 2 June 02.

Hyatt Pure Water Co, filtering apparatus. 77, V 2 No 1 Sept 87.

KNOWLES, MORRIS. Pittsburg, Pa, results of experiments. Ills, diags, and tables. 148-184, disc 185-188, V 15 No 2 Dec 00.

MILLS, H. F. Lawrence Water Works, Mass, filter and results. Diags. 44-55, disc 56, 57, V 9 No 1 Sept 94.

National Water Purifying Co filters. 76, V 2 No 1 Sept 87.

NORTHROP, F. L., Milford, Mass. 262-264, V 10 No 4 June 96.

Warsaw Water Works, Russia, covered filter. 103, V 7 No 2 Dec 92.

WESTON, R. S. New Albany, Ind, and Louisville, Ky. 15-18, V 13 No 1 Sept 98.

WHEELER, WILLIAM. Covered sand filter at Ashland, Wis. Diags and tables. 301-327, disc 327-329, V 11 No 4 June 97.

Filtration of sewage by bacterial methods. KINNICUTT, L. P. 119-141, disc 142-147, V 15 No 2 Dec 00.

Filtration of water. Methods: disc 30, 31, V 2 No 3 Mar 88.

BANCROFT, L. M. Iron removal plant, Reading, Mass. 294-300, V 11 No 4 June 97.

BRUSH, C. B. Aëration and filtration of water. 71-77, disc 78-85, V 2 No 1 Sept 87.

CLARK, H. W. A few words on. 82-87, V 14 No 1 Sept 99.

Removal of iron from ground waters. 277-280, disc 280-284, V 11 No 4 June 97.

DARLING, EDWIN. Disc. 165-166, V 3 No 4 June 89.

DROWN, Prof T. M. Filtration of natural waters. 91-99, V 5 No 2 Dec 90.

Virchow and Anderson processes. 81, 82, V 5 No 2 Dec 90.

- FITZGERALD, D., and others. Coloring matter in water, and methods of removal. 156-163, V 16 No 2 June 02.
- HAZEN, ALLEN. Removal of color by filtration. 32-34, V 12 No 1 Sept 97.
- ROGERS, H. W. 54-59, disc 59-63, trans 84.
- SEDGWICK, Prof W. T. Of surface waters. 33-39, disc 39-44, V 5 No 1 Sept 90.
History of. 331-336, V 15 No 4 June 01.
Purification of water by. 103-130, V 7 No 2 Dec 92.
Water supply sanitation in nineteenth century. 315-337, V 15 No 4 June 01.
- SWARTS, Dr G. T. Man's imitation of nature. 1-14, disc 15-19, V 13 No 1 Sept 98.
- TIDD, M. M. Practicability of filter galleries on borders of rocky ponds. 106-108, V 5 No 3 Mar 91.
- WESTON, E. B. Mechanical (sulphate of alumina). Diags. 333-353, disc 354-362, V 14 No 4 June 00.
- WESTON, R. S. Water supply of New Orleans, and its improvement. 157-171, disc 171-173, V 17 No 2 June 03.
- Financial management of water works.** COFFIN, F. C. Statistics. 63-86, disc 87-98, V 11 No 1 Sept 96.
- Fire boats.** McINNES, F. A. Boston salt water fire system. 304-313, V 13 No 4 June 99
- Fire engines, steam hydrants, and hose capacity tests and tables.** BRACKETT, DEXTER. 151-162, V 9 No 3 Mar 95.
- Fire protection.**
- ATKINSON, EDWARD. Relation of water-works engineers to fire service of factories. 58-63, disc 63-83, V 17 No 1 Mar 03.
- CHACE, G. F. Handling fires while changing mains, Taunton, Mass. 230-233, V 10 No 4 June 96
- CROSBY, E. U. Eliminating the conflagration hazard. 97-109, disc 110-118, V 15 No 2 Dec 00.
- ELLIS, G. A. Two methods of obtaining: by direct high pressure from water-works pumps in combined pumping, and reservoir or stand-pipe systems. 27-31, V 7 No 1 Sept 92
- FOSTER, JOEL. By whom should it be paid? 270-272, V 12 No 4 June 98.
- FREEMAN, J. R. Arrangement of hydrants and pipes for fire protection. Diags. 49-77, disc 77-81, V 7 No 1 Sept 92.
Arrangement of: disc. 152-164, V 7 No 3 Mar 93
For manufacturing establishments: disc. 176-179, V 7 No 3 Mar 93.
- GERHARD, W. P. For theaters and water service. 77-92, V 9 No 2 Dec 94.
- HASKELL, J. C. Water supply at fires. 47, 48, V 7 No 1 Sept 92.
- Knoxville Water Co. Applied to private plants. 299, V 16 No 4 Dec 02.

McINNES, F. A. Boston salt water fire system. 304-313, V 13 No 4 June 99.

New Bedford, Mass, city regulations. 431-435, V 15 No 5 Sept 01.

N E W W A. Reports, etc. See N E W W A, com on fire protection.

N E W W A, fire pipe committee. Private fire services. 201, 202, V 17 No 2 June 03.

Providence, R I, regulations. 436-438, V 15 No 5 Sept 01.

San Francisco, Cal, regulations for private fire supplies. 435, 436, V 15 No 5 Sept 01

Springfield, Mass, fire department. Hose discharge experiments. 152, trans 85.

TRYON, JAMES. What a water supply engineer can do for the fire department. 93-102, V 9 No 2 Dec 94.

WESTON, E. B. Separate high pressure system of Providence, R I. Diags. 85-91, disc 91-93, V 13 No 2 Dec 98.

Fire services. Should they be metered?

COGGESHALL, R. C. P., and others: disc. 27-33, V 6 No 1 Sept 91.

WALKER, C. K., and others: disc. 342, 343, V 11 No 4 June 97.

Fire streams. FREEMAN, J. R. Experiments and practical tables. 95-167, disc 168-171, V 4 No 3 Mar 90.

Fire supplies.

COGGESHALL, R. C. P., and others. Private and insurance regulations: disc. 193-197, V 9 No 4 June 95.

HAMMOND, J. C., and others. Private fire supply charges and control of service: disc. 406-440, V 15 No 5 Sept 01.

HAWES, W. M. Liability of town for insufficient supply. 104-106, V 5 No 3 Mar 91.

FRENCH, E. V. In manufactories, meters and loss of pressure. 74-94, disc 95-102, V 12 No 2 Dec 97.

McINNES, F. A. Fire system (salt water) of Boston, Mass. Diags. 304-313, V 13 No 4 June 99.

Fish in pipes (March and June). 61, trans 84.

JONES, E. R. Experience. 81, V 5 No 2 Dec 90.

Fish traps and meter obstruction. FRENCH, E. V. 86-88, V 12 No 2 Dec 97.

FitzGerald, Desmond, Pres N E W W A.

Address to N E W W A, 8 Jan 96, Boston. 147-149, V 10 No 3 Mar 96.

Address to N E W W A, 10 June 96, Lynn. 101-109, V 11 No 1 Sept 96.

Chemical analysis of water. 24, 25, V 2 No 3 Mar 88.

Coloring matter in water and removal. 156-163, V 16 No 2 June 02.

Covered reservoirs. 127, 128, V 8 No 3 Mar 94.

Covington reservoir water. 77, V 5 No 2 Dec 90.

Description of Croton aqueduct, N Y. 106-108, V 11 No 1 Sept 96.

- Desirability of water meters. 59, V 5 No 1 Sept 90.
 Diversion of water from streams for city supply. Diags and table.
 201, V 7 No 4 June 93.
 Effect of storage on quality of water. 124, 125, V 5 No 3 Mar 91.
 Filtration of water. 78, V 2 No 1 Sept 87.
 Filtration of water supplies. 40, 41, V 5 No 1 Sept 90.
 Lawrence Water Works, Mass, filter results. 56, 57, V 9 No 1 Sept 94.
 Meters: disc. 59, V 5 No 1 Sept 90.
 Micro-organisms and effect on water supply. 216-218, V 9 No 3
 June 95.
 Purification of surface water by natural forces. 150-155, V 11 No 2
 Dec 96.
 Rainfall: amount available for water supply. 41-48, disc 48-54, V 1
 No 1 Sept 86.
 Remarks at Amer W W A and N E W W A dinner, 21 Apr 85. 213-
 215, trans 85.
 Remarks on Sedgwick's biological analysis of water. 19-21, disc 21,
 22, V 2 No 4 June 88.
 Remarks on Sedgwick's recent progress in biological water analysis.
 60-64, V 4 No 1 Sept 89.
 Report on capacity of Sudbury river and Lake Cochituate water-
 sheds in time of drought. Diags. 12-21, tables 22-32, V 2 No 2
 Dec 87.
 Reservoir embankment and earth dam construction. 141-147, V 8
 No 3 Mar 94.
 Restriction of water waste. 63-67, V 1 No 1 Sept 86
 Sand and mechanical filters. 49-52, V 14 No 1 Sept 99.
 Sinking fund tables. 185, 186, V 6 No 4 June 92.
 Visit to Croton aqueduct, N Y. 161, 162, V 3 No 4 June 89.
 Water hammer. 77, 78, V 1 No 1 Sept 86.
Fixtures, House, inspection of. ALLIS, S. M., and others. Disc. 34-37,
 table 38, V 6 No 1 Sept 91.
Flanges (standard) for water pipes. COFFIN, F. C. Diags. 48-51, V 6
 No 1 Sept 91.
Flood water channel of the Altoona reservoirs, Pa. KNIGHT, C. W.
 Ills. diags. 151-162, V 14 No 2 Dec 99.
Flow of water in 36-inch and 30-inch compound pipe: measurements.
 HASTINGS, L. M. (Diags of velocity curves, DWIGHT PORTER).
 189-194, V 8 No 4 June 94. Remarks of G. A. ELLIS. 58-60.
 Reply of L. M. HASTINGS. 61, 62, V 9 No 1 Sept 94.
Flower, Maj Lamorock (London). Watershed areas as boundaries for
 sanitary districts. 131, 132, V 13 No 2 Dec 98.
Flushing street mains: necessity and methods.
 BROWN, J. H. Disc 70, 71, trans 85.
 HANCOCK, J. C. Springfield, Mass. 71-73, trans 85.
 HOWLAND, A. H. Terre Haute, Ind. 91, 92, trans 85.

- Folly of reckoning by gallons.** BROOKS, FREDERICK. 258-267, V 17 No 3 Sept 03.
- Foran, George J.** Comparison of high and low duty pumping engines on a small water-works plant. 166-169, V 14 No 2 Dec 99.
- Forbes, Fayette F., Pres N E W W A.**
Address to N E W W A eighteenth annual convention. 180-184, V 14 No 2 Dec 99.
Appearance of chara fragilis in reservoirs of public water supply. 252-254, V 10 No 4 June 96.
Cement-lined service pipes (Brookline). 44-48, disc 48-57, V 15 No 1 Sept 00.
Covered reservoir at Brookline. 113-117, diags 127, V 8 No 3 Mar 94.
Diatoms, Brookline reservoir. 25, V 11 No 1 Sept 96.
Driven wells as a source of water supply. 141, 142, disc 142-144, V 5 No 3 Mar 91.
Driven wells at Brookline. 195-199, disc 199-201, V 11 No 3 Mar 97.
Frictional head in a force main. Tables. 164, 165, disc 165-167, V 6 No 4 June 92.
Galvanized pipes in driven wells. 143, 144, V 5 No 3 Mar 91.
Improvement in pumping engines. 157-162, V 13 No 3 Mar 99.
Lead poisoning by water from lead service pipes. 58-60, disc 60-62, V 15 No 1 Sept 00.
Relative taste and odor imparted to water by some algæ and infusoria. 90-96, disc 96, 97, V 6 No 2 Dec 91.
Study of algæ growth in reservoirs and ponds. Diags. 196-204, disc 204-210, V 4 No 4 June 90.
- Forbes, Howard C., joint author with Stone, Charles A.** Electrolysis of water pipes. Diag. 25-36, disc 36-43, V 9 No 1 Sept 94.
- Forests, Influence on rainfall and the flow of streams.** SWAIN, Prof G. F. 11-26, V 1 No 3 Mar 87.
- Foss, W. E.** Electrolysis of water pipes: disc. 368, V 14 No 4 June 00.
- Foster, Joel.** Fire protection; by whom should it be paid? 270-272, V 12 No 4 June 98.
- Foundry committee.** See N E W W A, com on pipe specifications, etc.
- Fowler, Charles E.** The operation of a slow sand filter (Poughkeepsie, N Y). 209-227, disc 227-244, V 12 No 4 June 98.
- Franklin Water Works, N H.**
COFFIN, F. C. Covered reservoir. 254, 255, V 14 No 3 Mar 00.
FULLER, F. L. 160, 161, disc 161, 162, V 5 No 4 June 91; 82-87, V 7 No 1 Sept 92.
- Freeman, John R.**
Arrangement of hydrants and pipes for fire protection. Diags. 49-77, disc 77-81, V 7 No 1 Sept 92. Disc. 152-164, V 7 No 3 Mar 93.
Bursting of Portland reservoir, Me. Diags. 148-152, disc 152-154, V 8 No 3 Mar 94.
Curved pipe experiments. 114, V 14 No 2 Dec 99.

- Direct pumping systems. 76, V 6 No 2 Dec 91.
- Diversion of water from streams for city supplies. 196-198, V 7 No 4 June 93.
- Fire protection for manufacturing establishments. 176-179, V 7 No 3 Mar 93.
- Fire streams: some new experiments and practical tables. Diags. 95-167, disc 168-171, V 4 No 3 Mar 90.
- Meters in fire services: disc. 27-33, V 6 No 1 Sept 91.
- Minimum size of mains: disc. 18-20, V 6 No 1 Sept 91.
- Reservoir embankment construction. 134, 135, V 8 No 3 Mar 94.
- Freezing of hydrants.** See Hydrants.
- Freezing of pipes: prevention.** G. A. STACY. 201-203, V 12 No 3 Mar 98.
- Freezing, Purification of water by.** DROWN, Prof T. M. 46-52, V 8 No 1 Sept 93.
- French, E. V.**
- Gravity system for fire protection. 91, 92, V 13 No 2 Dec 98.
- Loss of pressure caused by meters in factory fire supplies: result of test; diags. 73-94, disc 94-102, V 12 No 2 Dec 97.
- Private fire supplies and charges: disc. 406-431, V 15 No 5 Sept 01.
- French covered reservoirs.** COFFIN, F. C. 253, V 14 No 3 Mar 00.
- Frequency of main valve examination:** disc. 70, 71, V 1 No 1 Sept 86.
- Fresh Pond, Cambridge, Mass.** NEVONS, HIRAM. 212, 213, V 4 No 4 June 90.
- Friction in collecting meter rates.** CHACE, G. F. 44-50, V 4 No 1 Sept 89.
- Friction in fire hose: tables.** FREEMAN, J. R. 108-111, V 4 No 3 Mar 90.
- Friction in several pumping mains.** COFFIN, F. C. Diags and tables. 234-243, V 10 No 4 June 96.
- Friction loss in separate fire service pipes:** disc. WESTON, E. B., and others. 91-93, V 13 No 2 Dec 98.
- Frictional head in a force main.** FORBES, F. F. Table. 164, 165, disc 165-167, V 6 No 4 June 92.
- Frost, Mr.** Public and private water works: disc. 20, 21, V 4 No 1 Sept 89.
- Frost, Protection of pipes from.** E. R. JONES. 125-127, V 3 No 3 Mar 89.
- Frozen hydrants.**
- BAILEY, G. I. Ill and table. 116-123, V 14 No 2 Dec 99.
- STACY, G. A. Location and examination of. 222-224, V 7 No 4 June 93.
- Frozen pipes during spring thaw.**
- RICHARDS, W. H., and others. Experience. 276, 277, V 10 No 4 June 96.
- WALKER, C. K. Thawing service pipes: experience. 220, V 7 No 4 June 93.
- Fteley, Alphonse.** Note of address on Croton aqueduct, N Y. 16, V 5 No 1 Sept 90.

Fuel.

SHERMAN, W. B. Pumping engine duties and consumption of fuel. 23, 24, trans 83.

Coal. HOLLIS, I. N. Economy in the use of coal for production of power. 32-40, disc 40-43, V 17 No 1 Mar 03.

Peat. ATKINSON, EDWARD. Fuel: what we don't know about it. 180-195, disc 195-200, V 17 No 2 June 03.

Fuel value. BARRUS, G. H. Calorific determination of. 48-51, disc 51-54, V 10 No 1 Sept 95.

Fuertes, Prof E. A. Hydraulic laboratory of Cornell University, Ithaca, N Y. Ills. 195-205, V 14 No 3 Mar 00.

Fuller, Frank E. Died 1 Aug 02. Obituary, 247, V 16 No 3 Sept 02.

Fuller, Frank L.

Back filling trenches: ramming and tamping. 171-173, V 6 No 4 June 92.

Covered reservoir at Franklin, N H. 160-161, disc 161, 162, V 5 No 4 June 91.

Covered reservoir at Methuen. 123, V 8 No 3 Mar 94.

Covering Natick reservoir with concrete roof. 383-397, disc 398-417, V 17 No 4 Dec 03.

Discussion of Mr Venner's paper on municipal use and waste of water. 374-377, V 17 No 4 Dec 03.

Excessive consumption of water. 236, V 9 No 4 June 95.

Franklin Water Works, N H. Diags. 82-87, V 7 No 1 Sept 92.

Furnishing motor power from municipal supply. 156, 157, V 6 No 4 June 92.

Laying 10-inch pipe in Leicester, Mass. 190, 191, V 4 No 4 June 90.

Lead service pipes. 26, 27, V 6 No 1 Sept 91.

Life of service pipes: experience. 221, V 7 No 4 June 93.

Meehanical filtration. 358-360, V 14 No 4 June 00.

Ratio of pumping capacity to maximum consumption: disc. 110-112, V 3 No 3 Mar 89. See Sherman, W. B.

Sinking fund tables. 103-105, disc 105-110, V 12 No 2 Dec 97.

Testing water pipe distribution systems. Ill. 330-335, disc 335-338, V 11 No 4 June 97.

Waltham supply well. 183, 184, V 6 No 4 June 92.

Ware Water Works, Mass. 49-62, disc 62, 63, V 2 No 1 Sept 87.

Water pipe trenches. 76, V 8 No 2 Dec 93.

Water supply sources. 128, V 6 No 3 Mar 92.

Webster Water Works, Mass. Tables and plan. 240-247, V 9 No 4 June 95.

Fuller, George W. Relative applicability of sand and mechanical filters. 32-43, disc 43-53, V 14 No 1 Sept 99.

Fuller, William B. Groined arches. 412-417, V 17 No 4 Dec 03.

Gages.

ELLIS, G. A. Discharge of mains determined by pressure gages. 19-26, V 1 No 1 Sept 86.

- GOULD, J. A. Recording gages. 65-69, V 5 No 1 Sept 90.
- PERRY, F. G. Recording pressure gages: use and advantage. 255-257, disc 257-261, V 10 No 4 June 96.
- SEYMOUR, C. W. S. Experience with anchor ice and a recording pressure gage, Hingham. 223-225, V 9 No 4 June 95.
- WINSLOW, G. E. Use of air in pressure gages. 248, V 9 No 4 June 95.
- Gale, James M.**
Glasgow Water Works, Scotland. 240-251, V 14 No 3 Mar 00.
Died 7 Sept 03. Obituary 303, V 17 No 3 Sept 03.
- Galvanized pipe.**
FORBES, F. F. Galvanized pipe in driven wells. 143, 144, V 5 No 3 Mar 91.
Newton Water Works: experience. 201, V 11 No 3 Mar 97.
- Gardner, Edwin P.** Light for night work. 168-170, V 7 No 3 Mar 93.
- Gardner, L. H., Pres Amer W W A.**
Address at dinner of Amer W W A and N E W W A, 21 Apr 85. 188-195, trans 85.
The soft answer: experience of superintendents of water works. 129-131, V 5 No 3 Mar 91.
- Garrett, Jesse.**
Making cast-iron pipe. Ills. 27-54, disc 55-62, V 11 No 1 Sept 96.
Died 27 Apr 99. Obituary 350, V 13 No 4 June 99.
- Gas, gasoline, and oil engines applied to pumping machinery.** COFFIN, F. C. Diag. 206-217, V 13 No 3 Mar 99.
- Gas works.** N E Gas and Coke Co, Everett works. 93-96, V 14, No 1 Sept 99.
- Gasoline pumping plant.** CODD, W. F. Nantucket Water Works. 174-176, V 16 No 3 Sept 02.
- Gate chamber.** SAVILLE, C. M. 204-208, V 16 No 3 Sept 02.
- Gate houses.**
HERSCHEL, CLEMENS. Newark, N J. E Jersey Water Co. Diags. 18-40, V 8 No 1 Sept 93.
HOWARD, J. L. Middlesex Fells reservoir, Met Water Works. Ill. 29-32, V 15 No 1 Sept 00.
- Gate packing.** 71, V 1 No 1 Sept 86.
- Gate plan, Lowell Water Works, Mass.** 1885. 74, trans 85.
- Gates, Breaks in.**
MANNING, G. E. 135-137, V 16 No 2 June 02.
NEVONS, HIRAM. Thirty-inch gate Fresh Pond, Cambridge: experience. 212, 213, V 4 No 4 June 90.
WALKER, C. K. Manchester, N H, 20-inch. 135-137, V 16 No 2 June 02.
- Gates and specials.** Method of location: disc. 13-15, V 3 No 1 Sept 88.
- Gauges.** See Gages.
- Gavel presented to N E W W A by Amer W W A,** 3 June 89. 6, V 4 No 1 Sept 89.

- Gem or torrent meters recommended.** FRENCH, E. V. 94, V 12 No 2 Dec 97.
- Geographical distribution of N E W W A members.** 32-35, V 16 No 1 Mar 02.
- Gerhard, William Paul.** Water service and fire protection for theaters. 77-92, V 9 No 2 Dec 94.
- Gibbs, Harry F.** How to obtain the best results in small pumping stations (Natick, Mass). Diags. 167-173, V 16 No 3 Sept 02.
- Gilbert, Julius C.** Electrolysis of pipes: disc. 43-46, V 10 No 1 Sept 95.
- Gill regulator, Tegel Water Works, Berlin.** SEDGWICK, Prof W. T. Plate V. 122, V 7 No 2 Dec 92.
- Glasgow Water Works, Scotland.** GALE, J. M. 240-251, V 14 No 3 Mar 00.
- Glover, Albert S.**
 Charge for hydrant service: disc. 28, V 1 No 1 Sept 86.
 Water-works records. 69-79, V 4 No 2 Dec 89.
- Good water obtainable only by eternal vigilance.** G. F. CHACE. 147-150, V 9 No 3 Mar 95.
- Goodnough, X. H.** Some results of the systematic examination of public water supplies. 65-78, disc 78-81, V 14 No 1 Sept 99.
- Goss, Prof W. F. M.** Abstract from report on test of Snow pumping engine (Indianapolis, Ind). 49, 50, V 13 No 1 Sept 98.
- Gould, John A.**
 Boston Water Works, water hammer and remedy. 57, 58, V 6 No 1 Sept 91.
 Recording gages. Diags. 65-69, V 5 No 1 Sept 90.
- Gow, Frederick W.**
 Cement-lined pipe: disc. 113-117, trans 85.
 Laying a 10-inch high service pipe across (Mystic) river, Medford. 195, 196, disc 196-203, V 12 No 3 Mar 98.
- Gow, Robert M.** Died 6 June 92. Obituary 88, V 7 No 1 Sept 92.
- Gowing, E. H.**
 Back filling trenches. 173-177, disc 177, 178, V 12 No 3 Mar 98.
 How I reduce pressure on a gravity system. 139-142, disc 142-145, V 17 No 2 June 03.
 Laying pipe across Malden river, Mass: experience. 257-259, V 12 No 4 June 98.
 Laying pipes across a stream: disc. 135-140, V 5 No 3 Mar 91.
 Standard specifications for water works. 168-171, disc 171-178, V 6 No 4 June 92.
- Grannis, Sherman E.** Died 10 Aug 93. Obituary 53, V 8 No 1 Sept 93.
- Grant, Hon Alexander L.** Address to N E W W A, 14 June 03. 118, V 17 No 1 Mar 03.
- Gravity system.**
 GOWING, E. H. How I reduce pressure on a gravity system. 139-142, disc 142-145, V 17 No 2 June 03.

- WESTON, E. B. Gravity system for fire protection. 85-90, disc 91-93, V 13 No 2 Dec 98.
- WHITLOCK, F. W. Gravity system of Waterbury, Conn. 80, V 5 No 2 Dec 90.
- Griffin, S. P.** Laying a 30-inch supply main (Lowell, Mass). 186, 187, V 6 No 4 June 92.
- Groined arches.** METCALF, LEONARD, and others. 398-417, V 17 No 4 Dec 03.
- Groove in hub of pipe.** HILL, W. R., and others: note. 36, disc 40, V 13 No 1 Sept 98.
- Ground water supplies.**
- BOWERS, GEORGE. Underground water. 127-132, disc 132-137, V 17 No 2 June 03.
- CLARK, H. W. Iron removed from, by coke filters. 277-280, disc 280-284, V 11 No 4 June 97.
- HAWES, L. E. Provincetown, Mass. 285-290, disc 291-293, V 11 No 4 June 97.
- HOLLIS, F. S. Color in. Diags. 99-101, V 13 No 2 Dec 98.
- Growth of organisms in Boston water pipes.** WHIPPLE, G. C. 1-17, disc 17-19, V 12 No 1 Sept 97.
- Grush, Benjamin S.** Died 3 May 91. Obituary 64, V 6 No 1 Sept 91.
- Hague, Charles A.** Electrical pumping plant. 184-195, disc 195-202, V 10 No 3 Mar 96.
- Hale, R. A.**
- Anchor ice: experience (Lawrence, Mass). 275, V 10 No 4 June 96.
- Formation of tubercles in iron and steel penstocks. Diag. 244-251, V 10 No 4 June 96.
- Halifax, N S, scraper.** KEATING, E. H. 22, V 5 No 1 Sept 90.
- Hall, Frank E., Pres N E W W A.** Portrait. 278, V 16 No 4 Dec 02.
- Address to N E W W A, 19 June 84, Lowell. 13-15, trans 84.
- Charge for hydrant service: disc. 29, V 1 No 1 Sept 86.
- Chemical analysis of water. 28, V 2 No 3 Mar 88.
- Diversion of water from streams for city supplies: disc. 198, V 7 No 4 June 93.
- Merits of various kinds of street mains. 107-112, disc 112-117, trans 85.
- Public and private water works. 17-24, V 4 No 1 Sept 89.
- Hall, Mayor John O. (Quincy, Mass.).**
- Address of welcome to N E W W A, Boston. 387, 388, V 16 No 4 Dec 02.
- Address to N E W W A, 20 Sept 00, Portland, Me. 218-220, V 15 No 2 Dec 00.
- Duties of municipalities regarding water supply. 9-17, disc 17-20, V 17 No 1 Mar 03.
- Reciprocal obligations of the management of a water supply system and the community. 338-348, V 17 No 4 Dec 03.

Hamburg-Altona Water Works. SEDGWICK, Prof W. T. Plate IX.
130, V 7 No 2 Dec 92.

Hammatt, E. A. W. Back filling trenches. 160-165, disc 166-172.
V 12 No 3 Mar 98.

Hammond, J. C., Jr, and others. Private fire supply charges and control
of service: disc. 406-440, V 15 No 5 Sept 01.

Hancock, Joseph C.

Cast iron *v* cement pipe: disc. 56, V 5 No 1 Sept 90.

Depth of lead necessary in pipe joints. 25, disc 25, 26, V 5 No 1 Sept
90.

Effect of water hammer on main pipes, and remedy. 11, disc 11-14,
V 5 No 1 Sept 90.

Flushing street mains (Springfield). 71-73, trans 85.

Inquiry in relation to size of pipes for Springfield water main. 150-
153, V 3 No 4 June 89.

Risks taken by city or town in having but one supply main. 59-62,
disc 62, 63, V 6 No 1 Sept 91.

Waste of water: disc. 56, 57, V 1 No 1 Sept 86.

Died 12 July 02. Obituary 247, V 16 No 3 Sept 02.

Handling fires while changing mains. 230-233, V 10 No 4 June 96.

Hardness of water. DROWN, Prof T. M. 135, V 6 No 3 Mar 92.

Harlow, Mellen S. Died 29 Dec 00. Obituary 298, V 15 No 3 Mar 01.

Harrington, John L.

Experience with sand blast. 166, 167, V 3 No 4 June 89.

Laying siphon under Broad canal, Cambridge, Diags. 90-95, V 7
No 2 Dec 92.

Died 16 Aug 95. Obituary 76, V 10 No 1 Sept 95.

Haskell, John C., Pres N E W W A.

Address to N E W W A, 8 Sept 97. Newport, R I. 57-60, V 12
No 1 Sept 97.

Cleaning reservoirs: disc. 29, 30, V 12 No 1 Sept 97.

Control of hydrants by firemen: disc. 144, V 10 No 3 Mar 96.

Cost of operating sand filters: disc. 238, 239, 241, V 12 No 4 June 98.

Distributing systems. 101, 103-106, 108-115, V 14 No 2 Dec 99.

Electrolysis (Lynn). 278-281, disc 281-286, V 10 No 4 June 96.

Experience with cement-lined pipe. 171-173, disc 173-175, V 7 No 3
Mar 93.

How to secure pure water from a surface water supply. 137-144,
disc 144-155, V 11 No 2 Dec 96.

Lynn fire supply. 169, 170, V 4 No 3 Mar 90.

Lynn pumping engine foundation. 163, 164, V 5 No 4 June 91.

Lynn water supply. 55-63, disc 63, 64, V 10 No 1 Sept 95.

Meter over-registration. 98, 101-106, V 10 No 2 Dec 95.

Reduction of excessive consumption of water. 231-233, disc 233-239,
V 9 No 4 June 95.

Removing organisms from water: disc. 216-219, V 14 No 3 Mar 00.

Surface water supplies of Mass. 79-84, V 13 No 2 Dec 98.

Systematic examination of public water supplies: disc. 81, V 14 No 1 Sept 99.

Water supply at fires: disc. 47, 48, V 7 No 1 Sept 92.

Died 12 June 00. Obituary 64, V 15 No 1 Sept 00; 200, V 15 No 2 Dec 00.

Hassam, Walter E. Worcester distributing reservoir. Diags. 153-158, disc 158, 159, V 12 No 3 Mar 98.

Hastings, Lewis M.

Cambridge Water Works. Diag, ills. 121-132, disc 132-136, V 11 No 2 Dec 96.

Measurements of flow of water in 36-inch and 30-inch compound pipe. 189-194, V 8 No 4 June 94. Disc 58-62, V 9 No 1 Sept 94.

Method of estimating loss of water power in stream. Diags and tables. 187-194, disc 195-201, V 7 No 4 June 93.

Reply to remarks of G. A. Ellis. 61, 62, V 9 No 1 Sept 04.

Use of steel for water mains. Ills. 314-324, V 13 No 4 June 99.

Hathaway, James H.

House inspection of fixtures: disc (Springfield). 34, table 38, V 6 No 1 Sept 91.

Methods of collecting water rates. 68, 69, disc 69-71, V 2 No 1 Sept 87.

Uniformity in water-works reports. 141, trans 85.

Haviland, Dr A. (England). Watershed areas and sanitary districts. 132, 133, V 13 No 2 Dec 98.

Hawes, Louis E.

Utilizing a spring as a source of water supply. Diags. 156-171, V 11 No 2 Dec 96.

Water supply of Provincetown, Mass. Map. 285-290, disc 291-293, V 11 No 4 June 97.

Hawes, W. H. See Hawes, William M.

Hawes, William M.

How they put the walking beam into the S S *Puritan*. 163, 164, V 3 No 4 June 89.

Inequalities in water rates: disc. 216, V 4 No 4 June 90.

Lead connections in service pipes. 86, 87, V 6 No 2 Dec 91.

Meters: disc. 68, V 1 No 1 Sept 86.

Need of more than one supply main: disc. 62, V 6 No 1 Sept 91.

Public and private water works: disc. 18, 19, V 4 No 1 Sept 89.

Reply to query as to liability of town in case of fire loss from insufficient fire supply. 104-106, V 5 No 3 Mar 91.

Report of fall meeting N E W W A, 29 Sept 89. 67, 68, V 4 No 2 Dec 89.

Water tanks: disc. 29-31, V 2 No 1 Sept 87.

Died 16 Feb 98. Obituary 292, V 12 No 4 June 98.

Hawkes, Mr. Cement-lined pipe (Malden). 40, trans 83.

Hawley, W. C. Results obtained by rotary and disc meters, Atlantic City, N J. Diag. 111-119, V 12 No 2 Dec 97.

Hazen, Allen.

Albany, N Y, filtration plant. Diags, ills. 291-332, V 14 No 4 June 00.

Covered filters and reservoirs. 327, 328, V 11 No 4 June 97.

European water supplies: notes. 109-121, disc 122-124, V 9 No 2 Dec 94.

Financial management of water works. 94-96, V 11 No 1 Sept 96.

Iron in ground waters. 280-283, V 11 No 4 June 97.

Iron in ground waters, Provincetown, Mass. 291, 292, V 11 No 4 June 97.

Lakes as sources of water supply and receptacles for sewage. 163-166, V 10 No 3 Mar 96.

Physical properties of water. 21-27, disc 27-31, V 17 No 1 Mar 03.

Removal of color by filtration. 32-34, V 12 No 1 Sept 97.

Sand and mechanical filters. 43-49, V 14 No 1 Sept 99.

Sand filters in America: tables and statistics. 227-231, 244, V 12 No 4 June 98.

Selection of sands for a filter. 165-168, V 7 No 3 Mar 93.

Headquarters of the N E W W A, Tremont Temple, Boston. Ill. 277, V 11 No 4 June 97.

Heald, Simpson C. Tanks for kitchen boilers: disc. 65, trans 85.

Henderson, N. C. WESTON, R. S. Occurrence of cristatella in storage reservoir. Map and diag. 20-26, disc 27-29, V 13 No 1 Sept 98.

Hering, Rudolph.

Experience with sand filters in Europe. 185-188, V 15 No 2 Dec 00.

Sewage purification and disposal. 142-145, V 15 No 2 Dec 00.

Herschel, Clemens.

Diversion of water from streams for city supply. 195, 196, V 7 No 4 June 93.

E Jersey Water Works for Newark, N J. Diags and tables. 18-40, V 8 No 1 Sept 93.

Electrical purification of water. 186-188, V 8 No 4 June 94.

European water supplies. 122, V 9 No 2 Dec 94.

Furnishing water power from municipal water supply: disc. 159, 160, V 6 No 4 June 92.

Tests of articles of commerce, to be conducted by N E W W A. 109-111, disc 111-116, V 10 No 2 Dec 95.

High and low duty pumping engines in a small water-works plant: comparison. SMITH, J. E. 163-166, disc 166-170, V 14 No 2 Dec 99.

High and low service standpipe, Atlantic Highlands, N J. Diags. BASSETT, C. P. 215-219, V 7 No 4 June 93.

High-grade pumping engines. LEAVITT, E. D. 163-183, disc 184-186, V 9 No 3 Mar 95.

High-pressure (direct) for fire protection. ELLIS, G. A. 27-31, V 7 No 1 Sept 92.

- High-service motor, Burlington, Vt.** PARKER, F. H. Diag. 63-66, disc 66-68, V 2 No 1 Sept 87.
- High-service pipe across Mystic river.** GOW, F. W. 195, 196, disc 196-203, V 12 No 3 Mar 98.
- High-service pumping engines.** DEAN, F. W. St Louis Water Works, Mo. 175-194, V 11 No 2 Dec 96.
- High-service station, Chestnut Hill (Met Water Works).** SANDO, W. J. Thirty million gallon pumping engine trial. 232-243, V 15 No 3 Mar 01.
- High-service water-works systems.**
 RICHARDS, W. H. New London, Conn. 148-151, V 7 No 3 Mar 93.
 WALKER, C. K. Manchester, N H. 66-68. Report of Rice & Evans, Engrs. Diags and ills. 68-75, V 10 No 1 Sept 95.
 WESTON, E. B. Providence, R I. Diags. 85-90, disc 91-93, V 13 No 2 Dec 98.
- High-water alarm for reservoirs and tanks.** WHITEMORE, W. P. Diag. 21-23, disc 23-25, V 3 No 1 Sept 88.
- Hill, William R.**
 Location and laying of 54-inch steel submerged pipe in Skaneateles lake, Syracuse Water Works, N Y. Diag. 40-45, V 8 No 1 Sept 93.
 Method of removing organisms from water of distributing reservoirs. Ills. 213-216, disc 216-229, V 14 No 3 Mar 00.
 Presentation from N E W W A at Syracuse meeting. 191, 192, V 14 No 2 Dec 99.
 Some things that should be done in constructing a distributing system of water works. 36-39, disc 40-48, V 13 No 1 Sept 98.
- Hodge, Thomas A.** Died 16 Dec 87. Obituary 36, V 2 No 3 Mar 88.
- Hodgson, John S.** Water meters in Europe. 107, 108, V 9 No 2 Dec 94.
- Holden, Andrew.** Died n d. Obituary 200, V 15 No 2 Dec 00.
- Holden, Horace G., Pres N E W W A.**
 Address to N E W W A, 8 June 92, Holyoke. 35, V 7 No 1 Sept 92.
 Best form of service box at street curbing. 41, V 1 No 1 Sept 86.
 Experience with water meters. 154-156, V 3 No 4 June 89.
 Flushing street mains (Lowell, plan, gates, and pipes). 73-80, trans 85.
 Frozen hydrants. 11, V 4 No 1 Sept 89.
 House inspection of fixtures. 36, V 6 No 1 Sept 91.
 Inequalities in water rates. 213-215, disc 215-218, V 4 No 4 June 90.
 Laying a 24-inch main under Nashua river. 254-256, disc 256-260, V 12 No 4 June 98.
 Laying a 700-foot pipe across Merrimac. 136, V 5 No 3 Mar 91.
 Lead connections for iron service pipes. 81, 82, disc 82-89, V 6 No 2 Dec 91.
 Licensing plumbers: disc. 26-28, V 1 No 1 Sept 86.
 Nashua, N H, Water Works. Ills. 249-255, V 16 No 4 Dec 02.
 Service boxes used on the Pennichuck Water Works, Nashua, N H. 310, V 15 No 4 June 01.

- Test of Venturi meter at Worcester, Mass. 159, V 12 No 3 Mar 98.
 Water meters: disc. 65, 66, V 1 No 1 Sept 86.
- Holland, Notes made in 1887.** LOCKE, A. W. 44-49, V 5 No 1 Sept 90.
- Hollis, Frederick S.**
 Methods for the determination of color and its relation to the character of the water. Diags. 94-111, disc 111-118, V 13 No 2 Dec 98.
 Removing organisms from water. 221-223, disc 223-229, V 14 No 3 Mar 00.
 Study of micro-organisms in water supplies. 64, V 14 No 1 Sept 99.
- Hollis, Frederick S., and Parker, Horatio N.** Chlamydomonas in Spot Pond (Met Water Works). Diags. 26-29, disc 30, 31, V 14 No 1 Sept 99.
- Hollis, Ira N.** Economy in the use of coal for production of power. 32-40, disc 40-43, V 17 No 1 Mar 03.
- Holmes, Charles J.** Address of welcome to N E W W A, Fall River, 12 June 89. 1, V 4 No 1 Sept 89.
- Horton, Sylvanus D.** Died 19 Apr 88. Obituary 27, V 2 No 4 June 88.
- Hose.**
 BRACKETT, D. Capacity tests. Tables. 151-162, V 9 No 3 Mar 95.
 FREEMAN, J. R. And fire streams. Ill, tables, and diags. 95-167, disc 168-171, V 4 No 3 Mar 90.
 GERHARD, W. P. Fire, for theaters. 83, 84, V 9 No 2 Dec 94.
 JONES, E. R. Fire hose. 168, V 4 No 3 Mar 90.
 Springfield fire department. Discharge experiments. 152, trans 85.
- Hose outlets on hydrants.** WINSLOW, G. E., and others. 26, 27, V 5 No 1 Sept 90.
- Hosley, Mayor, Manchester.** Address to N E W W A, 15 June 87. 1-4, V 2 No 1 Sept 87.
- Hotchkin, George A.** Died 6 Oct 02. Obituary 402, V 16 No 4 Dec 02.
- House inspection of fixtures.** ALLIS, S. M., HATHAWAY, J. H., and others. Disc. 34-37, specimen table 38, V 6 No 1 Sept 91.
- How to obtain best results in pumping.** GIBBS, H. F. 167-173, V 16 No 3 Sept 02.
- How to secure pure water.** HASKELL, J. C. 137-144, disc 144-155, V 11 No 2 Dec 96.
- How we painted our standpipe.** BEALS, J. E. 157, 158, V 3 No 4 June 89.
- Howard, John L.** Construction of the Middlesex Fells reservoir for the Met Water Works. Ills. 20-32, disc 33, V 15 No 1 Sept 00.
- Howe, Hon C. H.** Address to N E W W A, 11 Mar 03. 232, 233, V 17 No 2 June 03.
- Howland, A. H.**
 Blow-offs: disc. 83, 84, trans 85.
 Charge for hydrant service: disc. 29-31, V 1 No 1 Sept 86.
 Flushing laterals, Terre Haute, Ind. 91, 92, trans 85.
 Licensing plumbers: disc. 26-28, V 1 No 1 Sept 86.

Report of N E W W A com on classification of water rates. 15, 16,

V 1 No 1 Sept 86; 32-42, disc 42-44, V 2 N 1 Sept 87.

Testing of meters: disc. 80-86, V 3 No 2 Dec 88.

Weight of cast-iron pipe. 28, 29, trans 85.

Hub of pipes.

HILL, W. R., and others. Lead groove form: note. 36, disc 40, V 13
No 1 Sept 98.

MANNING, G. E. Cast iron: table of dimensions in inches. 133, 134,
V 16 No 2 June 02.

Hurley, John. Wenham lake water supply for Salem, Mass. 272, 273,
V 11 No 3 Mar 97.

Hyatt Pure Water Co filtering apparatus. Ill. 77, V 2 No 1 Sept 87.

Hyde, Horatio N.

Disjointing 12-inch iron pipe. 102, trans 85.

Flushing mains, Newton Water Works. 81, trans 85.

Testing Newton mains. 336, 337, V 11 No 4 June 97.

Water hammer. 73, 74, V 1 No 1 Sept 86.

Hydrants.

ALLIS, S. M. Economy in water-works management: disc. 161-163,
V 6 No 4 June 92.

ATKINSON, E., and others. Relation of water-works engineers to fire
service of factories. 58-63, disc 63-83, V 17 No 1 Mar 03.

BAILEY, G. I. Fire, care in winter. Ill, table. 116-123, V 14 No 2
Dec 99.

BILLINGS, W. R., and others. Service, Charge for: disc. 28-32, V 1
No 1 Sept 86.

BRACKETT, D. Capacity tests. Tables. 151-162, V 9 No 3 Mar
95.

FREEMAN, J. R. Arrangement for fire protection. Diags. 40-77,
disc 77-81, V 7 No 1 Sept 92; additional disc 152-164, V 7 No 3
Mar 93.

Location. 61-65, V 7 No 1 Sept 92.

HILL, W. R. Fire use, with special valve for sprinkling. 39, 40,
V 13 No 1 Sept 98.

How to set to prevent freezing: disc. 9-13, V 4 No 1 Sept 89.

KNAPP, L. H. Buffalo Water Works. Ills. Plates III, IV. 208,
V 14, No 3 Mar 00.

McINNES, F. A. Bachelder, for Boston salt water fire system. Diag.
304-313, V 13 No 4 June 99.

SNELL, G. H. Private hydrants, sprinklers, and insurance. 64, 65, 71,
V 17 No 1 Mar 03.

STACY, G. A. 32-37, disc 37, 38, V 4 No 1 Sept 89.

And broken mains: examination in cold weather. 222-224, V 7
No 4 June 93.

Experiment and failure: separation of pipe from hydrant. 24-26,
V 7 No 1 Sept 92.

WALKER, C. K. Use of water from, for skating rinks; disc. 143-146, V 10 No 3 Mar 96.

WINSLOW, G. E., and others. Hose outlets on; remarks. 26, 27, V 5 No 1 Sept 90.

Size; disc. 94-96, V 2 No 1 Sept 87.

Hydraulic laboratory.

FUERTES, Prof E. A. Cornell university, Ithaca, N Y. Ills. 195-205, V 14 No 3 Mar 00.

PORTER, Prof DWIGHT. Mass Inst of Technology, Boston. Ills. 81-84, V 8 No 2 Dec 93.

Hydraulic pumping machinery types. FANNING, J. T. Ills. 34-41, V 1 No 1 Sept 86.

Hydrostatic test of cast-iron pipe. 95, 106, 108, 114, 115, 123-127, V 16 No 2 June 02; 363, V 16 No 4 Dec 02.

Ice, Anchor. See Anchor ice.

Ice in standpipes.

COCHRAN, R. L., and others. 227-229, V 17 No 2 June 03.

COOK, B. I., and others. Disc. 129, 130, V 14 No 2 Dec 99.

Ice, Purity of. 46-52, V 8 No 1 Sept 93.

Improvement in pumping engines. FORBES, F. F. 157-162, V 13 No 3 Mar 90.

Indianapolis, Ind.

Goss, W. F. M. Test of Snow pumping engine. 49, 50, V 13 No 1 Sept 98.

Manufacturers Nat Gas Co. Street-railway demurrer to complaint over-ruled. 229-231, V 15 No 2 Dec 00.

Inequalities in water rates. HOLDEN, H. G. 213-215, disc 215-218, V 4 No 4 June 90.

Influence of forests upon rainfall. SWAIN, Prof G. F. 11-26, V 1 No 3 Mar 87.

Infusoria and algæ.

FORBES, F. F. Taste and odor imparted to water by. 90-96, disc 96, 97, V 6 No 2 Dec 91.

HOLLIS, F. S., and PARKER, H. N. Chlamydomonas in Spot pond (Met Water Works). Diags. 26-29, disc 30, 31, V 14 No 1 Sept 99.

WHIPPLE, G. C. In surface waters. 215, 216, V 9 No 4 June 95.

Raphidomonas in (Lynn) water. Ill. 348-357, V 11 No 4 June 97.

Inland waters of Mass, Act to protect. MILLS, H. F. 6-10, V 1 No 3 Mar 87.

Inquiry in relation to size of pipes. HANCOCK, J. C. 150-153, V 3 No 4 June 89.

Inspection (sanitary) work of Met Water Works. LOCKE, W. W. 483-489, disc 489-492, V 15 No 6 Dec 01.

Insurance. SNELL, G. H. Private hydrants, sprinklers, and insurance. 64, 65, 71, V 17 No 1 Mar 03.

- Insurance inspection.** ATKINSON, E., and others. 58-63, disc 63-83, V 17 No 1 Mar 03.
- Insurance requirements and private fire supplies.** COGGESHALL, R. C. P., and others: disc. 193-197, V 9 No 4 June 95.
- Iron in ground waters.** HAWES, L. E. Provincetown, Mass: experiment. 285-290, disc 291-293, V 11 No 4 June 97.
- Iron removal plant, Reading, Mass.** BANCROFT, L. M. 294-300, V 11 No 4 June 97.
- Iron removed by coke filters.** CLARK, H. W. 277-280, disc 280-284, V 11 No 4 June 97.
- Iron, scrap, pig, etc.** GARRETT, JESSE, and others. Use for pipe in foundries. 55-62, V 11 No 1 Sept 96.
- Iron v cement pipes.** STEBEN, B. F. 55, 56, V 5 No 1 Sept 90.
- Irrigation in Tucson, Arizona.** ALLIS, S. M. 252, 253, V 12 No 4 June 98.
- Is the game worth the candle?** THOMSON, JOHN. 58-67, V 8 No 2 Dec 93.
- Jacket pump.** GIBBS, H. F. Diag. 170, V 16 No 3 Sept 02.
- Jackson, D. D., and Whipple, George C.** Asterionella: its biology, chemistry, and effect on water supplies. Diags. 1-23, disc 23-25, V 14 No 1 Sept 99.
- Jackson, James F.** Relation of great ponds to water supplies. 203-208, V 3 No 4 June 89.
- Janin, George.** History and description of the Montreal Water Works. 272-283, V 17 No 3 Sept 03, disc 378-382, V 17 No 4 Dec 03.
- Japan, Water in.** CHAPLIN, W. S. 20-26, V 1 No 2 Dec 86.
- Jenkins, George S.** Died 12 Nov 00. Obituary 224, V 15 No 2 Dec 00.
- Jewell filter in Pittsburg filter plant.** KNOWLES, MORRIS. 167-176. Analysis of water. 184, V 15 No 2 Dec 00.
- Johnson, F. P.** Basin and well covering of Waltham Water Works, Mass. Diags. 120-122, disc 123-129, V 8 No 3 Mar 94.
- Joining pipes (Burlington, Vt).** CRANDALL, F. H. Ill. 159, 160, V 10 No 3 Mar 96.
- Joints and pipes.** Testing of: disc. 41-44, V 13 No 1 Sept 98.
- Joints of pipes.**
 BILLINGS, W. R., and others. Comparative value of wiped and cup: disc. 71, 72, V 1 No 1 Sept 86.
 BRAND, J. A., and others. Lead joints: disc. 94-105, trans 85.
 COFFIN, F. C. Cast-iron pipe, Yarmouth, N S. Ill. 38-42, disc 42, 43, V 15 No 1 Sept 00.
 COGGESHALL, R. C. P. Naphtha lamps for melting lead joints. 103, trans 85.
 FORBES, F. F. Cement-lined service pipes (Brookline, Mass). 48, V 15 No 1 Sept 00.
 GARDNER, E. P. Light for night work and melting lead joints. 168-170, V 7 No 3 Mar 93.

HANCOCK, J. C., and others. Lead, depth of: disc. 25, 26, V 5 No 1 Sept 90.

HILL, W. R., and others. Caulking of: disc. 41-43, V 13 No 1 Sept 98.

MANNING, G. E. Lead for cast-iron pipes. Design. 130-138, V 16 No 2 June 02.

MURDOCK, WILLIAM. Wooden joints in cast-iron water mains. St John, N B. 34-37, V 15 No 1 Sept 00.

Jones, E. R.

Fire hose. 168, V 4 No 3 Mar 90.

Fish catching inside pipes. 81, V 5 No 2 Dec 90.

Protection of pipes from frost. 125-127, V 3 No 3 Mar 89.

Journal of N E W W A. See N E W W A journal.

Joy, Moses.

Tanks for house supply. 66, trans 85.

Weights of cast-iron pipe (Milford). 29-31, trans 85.

Weights of cast-iron pipe, testing of weights. 39, trans 85.

Keating, E. H.

Frozen hydrants. 10, 11, V 4 No 1 Sept 89.

Halifax, N S, scraper. 22, V 5 No 1 Sept 90.

Private water works. 19, V 4 No 1 Sept 89.

Kempton, David Batchelder. Died 4 Mar 99. Obituary 349, V 13 No 4 June 99.

Kent, Willard, Pres N E W W A.

Address to N E W W A, 14 Sept 98, Portsmouth, N H. 60-62, V 13 No 1 Sept 98.

Charge for hydrant service. 29, V 1 No 1 Sept 86.

Kerosene pumping engine, Cohasset Water Works, Mass. Ill. 176, V 16 No 3 Sept 02.

Kieran, Patrick.

Loss of water from pipes: experience (Fall River). 250, 251, V 12 No 4 June 98.

Water tank at Fall River, Mass. Diag. 26, 27, disc 27-32, V 2 No 1 Sept 87.

Kiersted, Wynkoop. Water supply and its development for small western cities. 83-90, V 5 No 2 Dec 90.

Kimball, Frank C. Some 6-inch meter tests and how made. 305-331, disc 331-337, V 17 No 4 Dec 03.

Kimball, George A.

Diversion of water from streams for city supply: disc. 198, V 7 No 4 June 93.

Method of recording location of mains and services. Diags. 157-159, V 8 No 3 Mar 94.

Stealing water: experience. 187-190, V 4 No 4 June 90.

Kingsley, Chester W. Construction and maintenance of water works. 127-133, V 3 No 3 Mar 89.

Kinnicutt, Prof Leonard P.

Pollution of streams by manufactural wastes. 510-513, V 15 No 6 Dec 81.

Purification of sewage by bacterial methods. Diag. 119-141, disc 142-147, V 15 No 2 Dec 00.

Kittanning Point reservoirs, Altoona, Pa. KNIGHT, C. W. 151-162, V 14 No 2 Dec 99.

Knapp, Louis H. Buffalo Water Works, N Y. Ills. 206-212, V 14 No 3 Mar 00.

Knight, Charles W. Flood water channels of the Altoona, Pa, reservoirs. Ills and diags. 151-162, V 14 No 2 Dec 99.

Knowles, Morris. Experimental filter works at Pittsburg and results of experiments. Ills, tables, diags. 148-184, disc 185-192, V 15 No 2 Dec 00.

Knoxville Water Co. Standard metered fire connection applied to private plants. Diag. 299, V 16 No 4 Dec 02.

Knudson, A. A. Cause and effect of electrolytic action on underground piping systems. Ills. 244-255, disc 255-271, V 15 No 3 Mar 01.

Kuichling, E.

Distribution systems. 104-107, V 14 No 2 Dec 99.

On case of Moffett, Hodgkins & Clarke Co breaking of contract. 144-146, V 13 No 2 Dec 98.

Rochester Water Works, N Y, reports (abstract). 138-143, V 13 No 2 Dec 98.

Kutter's and Poncelet's formulæ: discharge of water mains. 18, 19, V 1 No 2 Dec 86.

Kutter family, Trautwine's appeal for aid for. 7, V 3 No 1 Sept 88.

Laing, William H. Died, 5 Aug 01. Obituary 456, V 15 No 5 Sept 01.

Lakes as sources of water supply and receptacles for sewage. HAZEN, A. 163-166, V 10 No 3 Mar 96.

Landscape problems in Middlesex Fells (Met Water Works). OLMSTED, F. L. Ills. 272-287, V 15 No 3 Mar 01.

Larned, Edward S. Drainage of swamps for watershed improvement. Ills. 36-44, disc 44-50, V 16 No 1 Mar 02.

Latham, Baldwin (London, England). Control of watershed areas. 129-131, V 13 No 2 Dec 98.

Lausen, Switzerland. SEDGWICK, Prof W. T. Typhoid fever epidemic. 327-331, V 15 No 4 June 01.

Lawrence Water Works, Mass.

CLARK, H. W. Experience with filters. 231-234, 241-243, V 12 No 4 June 98.

Typhoid fever from water supply, 1892-1898. 83-86, V 14 No 1 Sept 99.

COLLINS, M. F. Filter. 288-297, V 17 No 3 Sept 03.

DEAN, F. W. Pumping engine. Diag. 87, V 8 No 2 Dec 93.

MILLS, H. F. Filter and results. Diags. 44-55, disc 56, 57, V 9 No 1 Sept 94.

ROGERS, H. W. Diags. 6-9, V 1 No 2 Dec 86.

Laying, J. B. "The water meter": verses from "San Francisco Wasp." 69, V 1 No 1 Sept 86.

Laying of pipes.

BRACKETT, D. Raising or lowering of pipes. 198, 199, V 3 No 4 June 89.

CHACE, G. F. Sixteen-inch main across rocky stream and over dam (Taunton). 103-105, disc 105, V 9 No 2 Dec 94.

COFFIN, F. C., and others. Carelessness causing leakage: disc. 93, 94, V 11 No 1 Sept 96.

FULLER, F. L. Ten-inch pipe in Leicester, Mass. 190, 191, V 4 No 4 June 90.

GOW, F. W. Ten-inch high-service pipe across Mystic river. 195, 196, disc 196-203, V 12 No 3 Mar 98.

GOWING, E. H. Across Malden river. 257-259, V 12 No 4 June 98.
Crossing a stream with a main pipe (Ward's joint). 135-140, V 5 No 3 Mar 91.

GRIFFIN, S. P. Thirty-inch supply main (Lowell, Mass). 186, 187, V 6 No 4 June 92.

HARRINGTON, J. L. Siphon pipe under Broad canal, Cambridge. Diags. 90-95, V 7 No 2 Dec 92.

HERSCHEL, CLEMENS. Under Pequannock river (Newark, N J, Water Works). 33-35, V 8 No 1 Sept 93.

HILL, W. R. Directions for laying. 36-39, V 13 No 1 Sept 98.
Fifty-four inch steel submerged pipe (Skaneateles lake, N Y) for Syracuse Water Works, N Y. Diag. 40-45, V 8 No 1 Sept 93.

HOLDEN, H. G. Twenty-four-inch main under Nashua river. 254-256, disc 256-260, V 12 No 4 June 98.

RICHARDS, W. H. Twenty-inch main (New London, Conn). 178, 179, disc 179-181, V 4 No 4 June 90.

SAVILLE, C. M. Pipes and pipe laying for Met Water Works. 203-226, disc 226-230, V 17 No 2 June 03.

WALKER, C. K. Eight-inch main on Merrimac river bottom. 220, V 7 No 4 June 93.

Leach, Samuel B.

Tarrytown water supply, N Y. 136, V 6 No 3 Mar 92.

Died 28 June 92 Obituary 145, V 6 No 3 Mar 92.

Lead connections for iron service pipe. HOLDEN, H. G. 81, 82, disc 82-89, V 6 No 2 Dec 91.

Lead joints.

BRAND, J. A., and others. Joints: depth of bell: disc. 94-105, trans 85.

GARDNER, E. P. Joints by Wells light. 168-170, V 7 No 3 Mar 93.

MANNING, G. E. Joints for cast-iron water pipe. 130-138, V 16 No 2 June 02.

Lead pipes.

CHACE, G. F., and others. Poisoning from lead service pipes: disc.

54, 55, V 12 No 1 Sept 97.

FORBES, F. F. Poisoning. 58-62, V 15 No 1 Sept 00.

GARRETT, JESSE. History and ills. 28-32, V 11 No 1 Sept 96.

SEDGWICK, Prof W. T. Louis Philippe, Claremont. 316, 317, V 15 No 4 June 01.

Lead service pipes. RICHARDS, W. H. 22, 23, V 6 No 1 Sept 91.

Lead services, Wannacomet Water Works, Nantucket. CODD, W. F. Diag. 187, 188, V 9 No 3 Mar 95.

Leakage and waste of water.

At leaded joints of pipes: disc. 93, 94, V 11 No 1 Sept 96.

COFFIN, F. C., and others. Detected by telemeter and testing pumps: disc. 89-94, V 11 No 1 Sept 96.

CRANDALL, F. H. From underground pipes. 245-249, disc 249-258, V 12 No 4 June 98.

Detected by Bell waterphone. 73-75, trans 84.

FULLER, F. L. Detected by testing. Ill. 330-335, disc 335-338, V 11 No 4 June 97.

HASKELL, J. C. Caused by electrolysis (Lynn). 278-281, disc 281-286, V 10 No 4 June 96.

NEVONS, HIRAM, and others. Causes and prevention. 27-29, disc 30-47, trans 83.

Learned, Wilbur F.

Aëration and oxidation of water. 43, 44, V 5 No 1 Sept 90.

Ashland basin No 4 (Boston) and mixing and handling of concrete. Diags. 3-7, disc 8, V 2 No 2 Dec 87.

Boston street main flushing: letter. 81-83, trans 85.

Leavitt, E. D. A few examples of high-grade pumping engines. Diags. 163-183, disc 184-186, V 9 No 3 Mar 95.

Le Baron, Eugene P. Died 1 Dec 93. Obituary 160, V 8 No 3 Mar 94.

Leeds, Dr A. R. Filtration: disc. 79-84, V 2 No 1 Sept 87.

Leicester, Mass. FULLER, F. L. Laying 10-inch pipe. 190, 191, V 4 No 4 June 90.

Lesage, T. W. Service boxes of Montreal Water Works. 284-287, V 17 No 3 Sept 03.

Liability of town in case of fire loss. HAWES, W. M. 104-106, V 5 No 3 Mar 91.

Licensing of plumbers. HOWLAND, A. H., and others. Disc. 26-28, V 1 No 1 Sept 86.

Life of service pipes. FULLER, F. L. 221, V 7 No 4 June 93.

Light for night work. GARDNER, E. P. 168-170, V 7 No 3 Mar 93.

Light in relation to growth of diatoms. WHIPPLE, G. C. Diags and tables. 1-24, disc 25, 26, V 11 No 1 Sept 96.

- Lindley, W. H.** Report on European water supplies to Paris exposition: remarks of Prof W. T. Sedgwick on. 33-39, disc 39-44, V 5 No 1 Sept 90.
- Lining of service pipes.** CHACE, G. F., and others. Disc. 45-55, V 12 No 1 Sept 97.
- Linsley, Dr J. H.** Died 17 Feb 01. Obituary 364, V 15 No 4 June 01.
- Little Falls Water Works, N Y.** BABCOCK, S. E. 57-63, V 3 No 1 Sept 88
- Location of hydrants.** FREEMAN, J. R. 61-65, V 7 No 1 Sept 92.
- Location of mains and services.**
 BROWN, A. W. F. Card system of recording. 226-228, V 9 No 4 June 95.
 KIMBALL, G. A. Method of recording. Diags. 157-159, V 8 No 3 Mar 94.
- Locke, Augustus W.**
 Notes made in Holland, on canals, pumps, dykes, windmills, etc. 44-49, V 5 No 1 Sept 90.
 Died 14 May 93. Obituary 227, V 7 No 4 June 93.
- Locke, William W.** Work of sanitary inspection on Met Water Works. 483-489, disc 489-492, V 15 No 6 Dec 01.
- Lockwood, Joseph A.** Died 24 Aug 97. Obituary 72, V 12 No 1 Sept 97.
- London, England.**
 SEDGWICK, Prof W. T. Water supply: sand filtration. 127, 128, V 7, No 2 Dec 92.
 Report on Met water supply, with special reference to sand filtration, May, 1892. Inserted after 130, V 7 No 2 Dec 92.
 Sanitary condition of water supply, 1837, 319; in 1854, 320; in 1866, 322-326, V 15 No 4 June 01.
- Loretz, Arthur J. L.** Pumping engines. 226-233, disc 234-241, summary of disc 241-244, V 11 No 3 Mar 97.
- Loss of water.** See Leakage.
- Louisville, Ky, filter plant.** WESTON, R. S. 15-18, V 13 No 1 Sept 98.
- Lowell Water Works, Mass.**
 BOWERS, GEORGE. Tube well experiment. 67-76, V 9 No 2 Dec 94.
 Second plant: description. 226-229, V 10 No 4 June 96.
 Results of experiments. 30-33, disc 33-35, V 13 No 1 Sept 98.
 HOLDEN, H. G. Street flushing: gate plan. 73-80, trans 85.
 THOMAS, R. J. Service box. Diag. 313, V 15 No 4 June 01.
- Lugs on branches.** N E W W A, Corn on cast-iron pipe. Table. 96, V 17 No 1 Mar 03.
- Lynn fire supplies.** HASKELL, J. C. 169, 170, V 4 No 3 Mar 90.
- Lynn water supply.** HASKELL, J. C. 55-63, disc 63, 64, V 10 No 1 Sept 95.
- Lynn Water Works.** HASKELL, J. C. Pumping engine foundation. 163, 164, V 5 No 4 June 91.

Lyon, James W., Pres N E W W A.

Portrait. 276, V 16 No 4 Dec 02.

Address to N E W W A, 21 June 83. 16-18, trans 83.

Lyon's packing for gates. 71, V 1 No 1 Sept 86.

Macadam surfacing. WESTON, E. B. and others. Thawing by steam for trench making, Providence, R I. 90, 91, V 13 No 2 Dec 98.

McClallan, William C. Died 15 Sept 88. Obituary 99, V 3 No 2 Dec 88.

McClintock, W. E. Water pipe trenches *v* good roads. 71-77, V 8 No 2 Dec 93.

McGuire, James K., Mayor, Syracuse, N Y. Address to N E W W A 13 Sept 99. 176-179, V 14 No 2 Dec 99.

McInnes, Frank A. Salt water fire system of Boston. Diags. 304-313, V 13 No 4 June 99.

McKenzie, Theodore H. Stealing water. 66, 67, V 17 No 1 Mar 03.

Macksey, Henry V. Insurance inspectors and stealing water. 72-74, V 17 No 1 Mar 03.

McLaughlin, Thomas H. Died 17 Dec 93. Obituary 195, V 8 No 4 June 94.

McNally, William, and others. Meter registration: disc. 96, 97, 104, 105, V 10 No 2 Dec 95.

Macopin intake details, E Jersey Water Co. HERSCHEL, CLEMENS. Diag. 29, V 8 No 1 Sept 93.

Main, Charles T. Diversion of water from streams for city supply. 199-201, V 7 No 4 June 93.

Main pipe.

GOW, F. W. Laying 10-inch across Mystic river, Medford. 195, 196, disc 196-203, V 12 No 3 Mar 98.

GOWING, E. H. Crossing a stream: experience. 135, 136, disc 136-140, V 5 No 3 Mar 91.

Main supply. HANCOCK, J. C. Risk in having only one. 59-62, disc 62, 63, V 6 No 1 Sept 91.

Main valve. Frequency of examination: disc. 70, 71, V 1 No 1 Sept 86.

Mains.

ALLIS, S. M. Relaying street mains in Malden, Mass. Diag. 79, 80, V 5 No 2 Dec 90.

BRACKETT, DEXTER. Minimum size allowable for street mains: disc. 18-20, V 6 No 1 Sept 91.

BROWN, A. W. F. Card system of recording. 226-228, V 9 No 4 June 95.

BROWN, J. H. Necessity and method of flushing street mains. 70, 71, disc 71-92, trans 85.

CHACE, G. F. Care of. 131-134, V 5 No 3 Mar 91.

Handling fires while changing mains, Taunton, Mass. 230-233, V 10 No 4 June 96.

- Laying of 16-inch main across rocky stream and over dam (Taunton).
103-105, disc 105, V 9 No 2 Dec 94.
- COFFIN, F. C. Friction in pumping mains. Table. 234-243, V 10
No 4 June 96.
- ELLIS, G. A. Discharge as determined by pressure gage. Diags.
19-26, V 1 No 1 Sept 86.
- FORBES, F. F. Frictional head in a force main. 164, 165, disc 165-167,
V 6 No 4 June 92.
- FREEMAN, J. R. Arrangement for fire protection. Diags. 49-77,
disc 77-81, V 7 No 1 Sept 92; 152-164, V 7 No 3 Mar 93.
- GRIFFIN, S. P. Laying of 30-inch supply main (Lowell, Mass). 186,
187, V 6 No 4 June 92.
- HALL, F. E. Merits of various kinds of street mains: disc. 107-117,
trans 85.
- HANCOCK, J. C. Risk in having only one supply main. 59-62, disc
62, 63, V 6 No 1 Sept 91.
Size and material for Springfield main: disc. 150-153, V 3 No 4
June 89.
Water hammer on mains, and remedy. 11, disc 11-14, V 5 No 1
Sept 90.
- HASTINGS, L. M. Steel for water mains. Ills. 314-324, V 13 No 4
June 99.
- HOLDEN, H. G. Laying of 24-inch under Nashua river. 254-256,
disc 256-260, V 12 No 4 June 98.
- KIMBALL, G. A. Method of recording location of mains and services.
157-159, V 8 No 3 Mar 94.
- MURDOCK, WILLIAM. Cast iron: wooden joints in, St John, N B.
34-37, V 15 No 1 Sept 00.
Cleaning, St John, N B. 147-151, V 13 No 2 Dec 98.
Cleaning, St John, N B. 333-341, disc 341-344, V 13 No 4 June
99.
Prevention of accumulation of sediment in. 16, 17, V 4 No 1
Sept 89.
- RICHARDS, W. H. Laying of 20-inch, New London, Conn. 178, 179,
disc 179-181, V 4 No 4 June 90.
- STACY, G. A. Location of broken mains and examination of hydrants
in cold weather. 222-224, V 7 No 4 June 93.
- TILDEN, J. A. Repairs on wrought iron. 202, V 3 No 4 June 89.
- TRAUTWINE, J. C., Jr. Letter in regard to Poncelet's and Kutter's
formule. 18, 19, V 1 No 2 Dec 86.
- WALKER, C. K. Laying an 8-inch main on Merrimac river bottom.
220, V 7 No 4 June 93.
- Malden, Mass.**
- ALLIS, S. M. Pipe system. 164, 165, V 5 No 4 June 91.
Relaying mains. Diags. 79, 80, V 5 No 2 Dec 90.
- Malden cement-lined pipe.** HAWKES, Mr. 40, trans 83.

Manchester Water Works, N H.

- WALKER, C. K. Gate boxes. 341, 342, disc 343, V 11 No 4 June 97.
 High service. Short history. 66-68. Diags, ills, and report of
 engineers, G. S. Rice & G. E. Evans. 68-75. V 10 No 1 Sept 95.
 Stave pipe first used 1874. 248. Described. 287, V 13 No 4
 June 99.

Manning, George E. Design of lead joints for cast-iron pipe. 130-138,
 V 16 No 2 June 02

Manufactories.

FREEMAN, J. R. Fire protection for manufacturing establishments.
 176-179. V 7 No 3 Mar 93.

WALKER, C. K., and others. Fire protection for manufacturing estab-
 lishments: disc. 176-179, V 7 No 3 Mar 93.

Manufactural wastes. CLARK, H. W. Polluting streams. 500-510,
 disc 510-513. V 15 No 6 Dec 01.

**Manufacturers Nat Gas Co v Indianapolis Street R R Co for damages to
 pipes by electrolysis.** 229-231, V 15 No 2 Dec 00.

Marlboro Water Works, Mass. STACY, G. A. Ills. 139-150, V 16 No 2
 June 02.

Marsh, Henry A., Mayor of Worcester. Address to N E W W A. 14 June
 93. 1, 2, V 8 No 1 Sept 93.

Martin, Cyrus B. Died 2 Apr 02. Obituary 125. V 17 No 1 Mar 03.

Martin, Robert K. Died 24 Nov 93. Obituary 160, V 8 No 3 Mar 94.

Mason, William P. Drinking water and disease: notes. 139-144. V 6
 No 3 Mar 92.

Masonry, Concrete of Forbes Hill reservoir, Met W W. SAVILLE, C. M.
 191-204, V 16 No 3 Sept 02.

Masonry dams. NOYES, A. F. Comparative sections. Diags. 124
 V 10 No 2 Dec 95.

Massachusetts great ponds water law.

MILLS, H. F. Act to protect inland waters. 6-10, V 1 No 3 Mar 87.

STETSON, T. M. 1-18, V 1 No 4 June 87.

Massachusetts Institute of Technology, Hydraulic laboratory. PORTER,
 Prof DWIGHT. Ills. 81-84, V 8 No 2 Dec 93.

Massachusetts Metropolitan water supply. NOYES, A. F. Maps and
 diags. 117-129, V 10 No 2 Dec 95.

Massachusetts surface water supplies. HASKELL, J. C. 79-84, V 13
 No 2 Dec 98.

Matthews, Nathan, Mayor of Boston. Address to N E W W A thirteenth
 convention. 1-5, V 9 No 1 Sept 94.

Mattice, Asa M. Pumping engines: disc. 235-241, V 11 No 3 Mar
 97.

Mayberry, G. S., Mayor of Waltham. Address to N E W W A, 14 Jan 91.
 102, 103, V 5 No 3 Mar 91.

Mechanical filtration (sulphate of alumina). WESTON, E. B. Diags.
 333-353, disc 354-362, V 14 No 4 June 00.

Mechanical and sand filters.

FULLER, G. W. 32-43, disc 43-53, V 14 No 1 Sept 99.

SWARTZ, G. T. 1-14, disc 15-19, V 13 No 1 Sept 98.

Menilmontant, France. SWAN, C. H. Covered reservoir: description. 51, 52, V 3 No 1 Sept 88.

Merits of various kinds of street mains. HALL, F. E. 107-112, disc 112-117, trans 85.

Merrill, Frank E., Pres N E W W A. Portrait. 100, V 17 No 1 Mar 03.
Address to N E W W A, 14 Jan 03, twenty-second annual meeting. 101-108, V 17 No 1 Mar 03.

Service box, Somerville Water Works. Diags. 306, 307, V 15 No 4 June 01.

Merrimac river. HOLDEN, H. G. Pipe across. 136, V 5 No 3 Mar 91.

Metals, Poisonous, conveyed by water. SEDGWICK, Prof W. T. Blue Hills case, Milton, Mass. 317, 318, V 15 No 4 June 01.

Metcalf, Leonard.

Data relating to groined arches in the United States. Tables. 398-417, V 17 No 4 Dec 03.

Echo Lake dam at Milford, Mass. Diags and ills. 146-156, V 17 No 2 June 03.

Metered service. CRANDALL, F. H. Methods of assessment and collection. 133-142, disc 143-150, V 14 No 2 Dec 99.

Meter, Water. Verses by J. B. Laying from "San Francisco Wasp." 69, V 1 No 1 Sept 86.

Meters.

BAILEY, G. I. Effect on water consumption in larger United States cities. 351-359, V 15 No 4 June 01.

BALDWIN, C. H., and others. As detectors of waste and leakage. 34, 35, trans 83.

BALL, PHINEHAS, and others. Disc. 41-46, trans 83.

CHACE, G. F., and others. Advisability of meters and city ownership: disc. 21, 22, V 6 No 1 Sept 91.

Friction in rate collection. 44-50, V 4 No 1 Sept 89; 230-237, disc 238, 239, V 14 No 3 Mar 00.

COGGESHALL, R. C. P., and others. In fire service: disc. 27-33, V 6 No 1 Sept 91.

CRANDALL, F. H. In by-pass to determine value and amount of water used. Table, diag. 344-347, V 11 No 4 June 97.

FRENCH, E. V. In factory fire supplies. 73-94, disc 95-102, V 12 No 2 Dec 97.

HAMMOND, J. C., and others. Private fire supply, charges and control of: disc. 421-430, V 15 No 5 Sept 01.

HASKELL, J. C. Use in distributing systems. 102, 103, 109, V 14 No 2 Dec 99.

HAWLEY, W. C. Results of meter system, Atlantic City, N. J. Diag. 111-119, V 12 No 2 Dec 97.

- HAZEN, ALLEN. Venturi meter on private fire supply. 295, V 16 No 4 Dec 02.
- HERSCHEL, CLEMENS. Tests of articles of commerce to be conducted by N E W W A. 109-111, disc 111-116, V 10 No 2 Dec 95.
- HOLDEN, H. G. Experience with. 154-156, V 3 No 4 June 89.
Test of Venturi meter, Worcester. 159, V 12 No 3 Mar 98.
- KIMBALL, F. C. Some 6-inch meter tests. 305-331, disc 331-337, V 17 No 4 Dec 03.
- RICE, L. F. Method and apparatus in recent tests at Boston. Diags. 67-79, disc 80-89, V 3 No 2 Dec 88.
Remarks on meter tests. 120-125, V 3 No 3 Mar 89.
- ROBERTSON, R. A. Venturi meter. Diags and ills. 32-42, disc 43-47, V 7 No 1 Sept 92.
- ROULLIER, G. A. Advisability of use. Table. 56-58, disc 59-65, V 5 No 1 Sept 90.
- TAYLOR, L. A., and others. 57-60, disc 60-68, V 1 No 1 Sept 86.
Experience with water meter. 182, V 6 No 4 June 92.
- Testing of: disc. 93, V 2 No 1 Sept 87.
- THOMSON, JOHN. Is the game worth the candle? (Commercial side of question.) 58-67, V 8 No 2 Dec 93.
Uniformity in testing. 77-96, disc 96-108, V 10 No 2 Dec 95.
- WALKER, C. K., and others. On pipes for fire service: disc. 342, 343, V 11 No 4 June 97.
- WHITNEY, J. C. Care of. 106, 107, disc 107, 108, V 9 No 2 Dec 94.
- Meterological conditions affecting water supply.** NILES, Prof. W. H. 74, 75, V 5 No 2 Dec 90.
- Methuen covered reservoir.** FULLER, F. L. 123, V 8 No 3 Mar 94.
- Metric system.** BROOKS, FREDERICK. Folly of reckoning by gallons while all countries have identical liters and cubic meters. 258-267, V 17 No 3 Sept 03.
- Metropolitan water supply of Mass.** NOYES, A. F. Nashua river watershed and reservoir. Map and diags. 117-129, V 10 No 2 Dec 95.
- Metropolitan Water Works.**
- BRACKETT, DEXTER. Pipes. 325-332, V 13 No 4 June 99.
- HOLLIS, F. S., and PARKER, H. N. Spot pond reservoir (Middlesex Fells), Chlamydomonas in. Diags. 26-29, disc 30, 31, V 14 No 1 Sept 99.
- HOWARD, J. L. Fells reservoir construction. Ill. 20-32, disc 33, V 15 No 1 Sept 00.
- KNUDSON, A. A., and others. Forty-eight-inch main showing effect of electrolytic action. 256, V 15 No 3 Mar 01.
- LOCKE, W. W. Sanitary inspection. 483-489, disc 489-492, V 15 No 6 Dec 01.
- N E W W A visit. 12 Sept 02. 394-398, V 16 No 4 Dec 02.
- OLMSTED, F. L. Landscape problems in improvement of Middlesex Fells. Ills. 272-287, V 15 No 3 Mar 01.

- SANDO, W. J. Pumping engine (30,000,000 gallon) Chestnut hill high service station. 232-243, V 15 No 3 Mar 01.
Pumping machinery. Diags, ills. 299-304, V 15 No 4 June 01.
- SAVILLE, C. M. Pipes and pipe laying. 203-226, disc 226-230, V 17 No 2 June 03.
Reservoir and standpipe construction (Forbes hill). 177-222, V 16 No 3 Sept 02.
Swamp ditches, Framingham and Sudbury reservoirs. Map. 47, V 16 No 1 Mar 02.
- Micro-organisms.** SEDGWICK, Prof W. T. Plankton method for study of micro-organisms. 57-64, V 14 No 1 Sept 99.
- Micro-organisms in surface waters.** WHIPPLE, G. C. Diags. 202-216, disc 216-222, V 9 No 4 June 95.
- Microscopical analysis of water.** DROWN, Prof T. M. 79-91, V 4 No 2 Dec 89.
- Microscopy of drinking water.** WHIPPLE, G. C. 59-62, V 14 No 1 Sept 99
- Middleboro, Mass.** BEALS, J. E. How we painted our reservoir or standpipe. 157, 158, V 3 No 4 June 89.
- Middlesex Fells reservoir construction (Met Water Works).**
HOWARD, J. L. Ills. 20-32, disc 33, V 15 No 1 Sept 00.
OLMSTED, F. L., jr. Spot pond improvement: landscape problems. Ills. 272-287, V 15 No 3 Mar 01.
- Middleton, R. E.** Watershed areas and sanitary districts coterminous. 119-129, disc 129-137, V 13 No 2 Dec 98.
- Milford Water Works, Mass, filter.** NORTHROP, F. L. 262-264, V 10 No 4 June 96.
- Miller, Edward F.** Waste heat engines. Diags. 44-50, disc 50, 51, V 17 No 1 Mar 03.
- Mills, Hiram F.**
Lawrence Water Works filter and results. Diags. 44-55, disc 56, 57, V 9 No 1 Sept 94.
Mass State Board of health. Act to protect inland waters of Mass. 6-10, V 1 No 3 Mar 87.
Typhoid fever in its relation to water supplies. 149-156, disc 156-160, V 5 No 4 June 91.
- Mills.**
HAMMOND, J. C., and others. Private fire protection supplies: disc. 406-431, V 15 No 5 Sept 01.
RAYMOND, W. G. Damages to mill powers. 152-156, V 13 No 2 Dec 98.
- Milne, Peter.**
Address at Amer W W A and N E W W A dinner, 21 Apr 85. 201, 202, trans 85.
Electrolysis. 46, 47, V 10 No 1 Sept 95.
Lead service pipes. 88, V 6 No 2 Dec 91.

- Water meters. 108, V 9 No 2 Dec 94.
- Milwaukee fire cisterns.** BENZENBURG, G. H. Arrangement of pipes, etc, for fire protection. Diag. 155-159, V 7 No 3 Mar 93.
- Mississippi river water.** WESTON, R. S. 161-168, V 17 No 2 June 03.
- Moat, Charles P.** Vermont water supplies: table of analyses. 514-521, V 15 No 6 Dec 01.
- Moffett, Hodgkins & Clarke case:** remarks of E. KUICHLING. 144-146, V 13 No 2 Dec 98.
- Molds for cast-iron water pipes.** MANNING, G. E. 126-129, V 16 No 2 June 02.
- Monte Rouge: Paris.** SWAN, C. H. Covered reservoir. 53, V 3 No 1 Sept 88.
- Montreal Water Works.**
 JANIN, GEORGE. History of Montreal Water Works. 272-283, V 17 No 3 Sept 03, disc 378-382, V 17 No 4 Dec 03.
 LESAGE, T. W. Service boxes. Ill. 284-287, V 17 No 3 Sept 03.
 PITCHER, F. H. Pumping by electricity. 349-373, V 17 No 4 Dec 03.
- Morse, Charles H.** Electrolysis of pipes. 367, 368, V 14 No 4 June 00; 139-145, disc 145-147, V 7 No 3 Mar 93.
- Morse, James W.** Died 23 Sept 99. Obituary 193, V 14 No 2 Dec 99; 200, V 15 No 2 Dec 00.
- Motor, Burlington, Vt.** PARKER, F. H. High service motor. Diag. 63-66, disc 66-68, V 2 No 1 Sept 87.
- Motor power: reasons why it should not be furnished from municipal water supply.** TUBBS, J. N. 152-155, disc 155-160, V 6 No 4 June 92.
- Mulhouse, Germany.** SWAN, C. H. Covered reservoirs. 49-51, V 3 No 1 Sept 88.
- Municipal ownership of water works:** address of Mayor Nathan Matthews to N E W W A, 14 June 94. 1-5, V 9 No 1 Sept 94.
- Municipal use and waste of water.** VENNER, JOHN. 268-271, V 17 No 3 Sept 03; disc 374-377, V 17 No 4 Dec 03.
- Municipal water supply.**
 HANCOCK, J. C. Risks to city or town in having but one supply main. 59-62, disc 62, 63, V 6 No 1 Sept 91.
 HASTINGS, L. M. Loss of water power by taking for city supply. 187-194, disc 195-201, V 7 No 4 June 93.
 TUBBS, J. N. Reasons why motor power should not be furnished. 152-155, disc 156-160, V 6 No 4 June 92.
- Municipal Water Works.**
 BAKER, M. N. Uniformity wanted in reports of. 189-192, V 15 No 2 Dec 00.
 COFFIN, F. C. Are they self-supporting? Diags. 63-86, disc 86-98, V 11 No 1 Sept 96.
- Murdock, William.**
 Cleaning a main. 333-341, disc 341-344, V 13 No 4 June 99.
 Cleaning of mains (St John, N B). 147-151, V 13 No 2 Dec 98.

- Wooden joints in cast-iron water mains. 34-37, V 15 No 1 Sept 00.
- Murphy, Charles F.** Died 6 Apr 99. Obituary 193, V 14 No 2 Dec 99.
- Nantucket, Mass, Wannacomet Water Works.**
- CODD, W. F. Filter at Wannacomet. Diag. 171-174, V 8 No 4 June 94.
- Method of connecting lead services. Diag. 187, 188, V 9 No 3 Mar 95.
- Pumping engines. Ills. 174-176, V 16 No 3 Sept 02.
- Naphtha lamps for melting lead joints.** COGGESHALL, R. C. P. 103, trans 85.
- Nashua, N H.**
- HOLDEN, H. G. Water supply. Ills. 249-255, V 16 No 4 Dec 02.
- Pipe under Nashua river. 254-256, disc 256-260, V 12 No 4 June 98.
- Nashua-Sudbury aqueduct.** NOYES, A. F. Sections. Diag. 127, V 10 No 2 Dec 95.
- Nason, William E.** Died 10 Oct 96. Obituary 275, V 11 No 3 Mar 97.
- Natick, Mass, covered reservoir.** FULLER, F. L. 383-397, disc 398-417, V 17 No 4 Dec 03.
- National fire protection association.** CROSBY, E. U. Automatic sprinkler regulations, 1896. 103-109, V 15 No 2 Dec 00.
- National Water Purifying Co filter.** Ill. 76, V 2 No 1 Sept 87.
- Natural water filtration.** DROWN, Prof T. M. 91-99, V 5 No 2 Dec 90.
- Natural waters.**
- DROWN, Prof T. M. Effect of aëration on. Tables and diags. 96-102, V 7 No 2 Dec 92.
- HOLLIS, F. S. Standards for detecting color of. 104-105, V 13 No 2 Dec 98.
- Necessity and method of flushing mains.** BROWN, J. H. 70, 71, disc 71-92, trans 85.
- Necessity for large-sized pipes.** DARLING, EDWIN. 180, V 4 No 4 June 90.
- Necessity for tank in supplying water.** BILLINGS, W. R. 51-56, disc 56-68, trans 85.
- Nevons, Hiram, Pres N E W W A.**
- Address to N E W W A, 12 June 89, Fall River. 3-5, V 4 No 1 Sept 89.
- Causes and prevention of the waste of water. 27-29, disc 30-47, trans 83.
- Experience with a 30-inch gate (Fresh pond). 212, 213, V 4 No 4 June 90.
- Inspection of meters: disc. 66, 67, V 1 No 1 Sept 86.
- Pipe cleaning: disc. 23, 24, V 5 No 1 Sept 90.
- Water pipe trenches. 76, V 8 No 2 Dec 93.
- Died 27 May 94. Obituary 63, V 9 No 1 Sept 94.

- New Albany, Ind.** WESTON, R. S. Filter plant. 15-18, V 13 No 1 Sept 98.
- New Bedford, city regulations for use of private fire supplies.** 431-435, V 15 No 5 Sept 01.
- New Bedford Water Works, Mass.**
 COGGESHALL, R. C. P. Cleaning distributing reservoir. 210, 211, disc 211, 212, V 4 No 4 June 90.
 Service box. Plate I. 308, V 15 No 4 June 01.
 Temporary dam. 200, 201, V 3 No 4 June 89.
- N E W W A. Visit of N E W W A. 6 June 98. 35-57, V 13 No 1 Sept 98.
- WOOD, EDMUND. Further water supply construction. Diags and ills. 202-219, disc 219-225, V 11 No 3 Mar 97.
- New England Gas and Coke Co, Everett works: description.** 93-96, V 14 No 1 Sept 99.
- New England Water Works Association. Addresses.**
 ALGER, A. R. 14 Jan 91. 102, V 5 No 3 Mar 91.
 ARNOLD, Col OLNEY. 21 Apr 85. 215-219, trans 85.
 BANCROFT, Hon W. A. 14 Mar 94. 167-170, V 8 No 4 June 94.
 BATCHELDER, G. E. 14 June 94. 6-8, V 9 No 1 Sept 94.
 BESSOM, Mayor of Lynn. 11 Mar 96. 291-293, V 10 No 4 June 96.
 10 June 96. 99-101, V 11 No 1 Sept 96.
 BOOTHBY, F. E. 18 Sept 01. 445-447, V 15 No 5 Sept 01.
 BOYLE, Mayor of Newport. 8 Sept 97. 56, V 12 No 1 Sept 97.
 BRACKETT, DEXTER. 11 June 90. 2-4, V 5 No 1 Sept 90.
 BRACKETT, J. Q. A. 21 Apr 85. 206-209, trans 85.
 CHACE, G. F. 14 June 93. 3-5, V 8 No 1 Sept 93.
 COCHRANE, JAMES. 9 Sept 03. 420, V 17 No 4 Dec 03.
 COGGESHALL, R. C. P. 16 June 86. 5-9, V 1 No 1 Sept 86.
 COOK, B. I. 19 Sept 00. 193-200, V 15 No 2 Dec 00.
 CRANDALL, F. H. 8 Jan 02. 66-69, V 16 No 1 Mar 02.
 DARLING, EDWIN. 13 June 88. 2, 3, V 3 No 1 Sept 88.
 DWIGHT, H. C. 10 June 91. 1-4, V 6 No 1 Sept 91.
 ELLIS, G. A. 29 Jan 85. 162-164, trans 85.
 21 Apr 85. 185-188, trans 85.
 18 June 85. 17-21, trans 85.
 FITZGERALD, DESMOND. 21 Apr 85. 213-215, trans 85.
 8 Jan 96. 147-149, V 10 No 3 Mar 96.
 10 June 96. 101-109, V 11 No 1 Sept 96.
 FORBES, F. F. 13 Sept 99. 180-184, V 14 No 2 Dec 99.
 GARDNER, L. H. 21 Apr 85. 188-195, trans 85.
 GRANT, Hon A. L. 14 June 03. 118, V 17 No 1 Mar 03.
 HALL, F. E. 19 June 84. 13-15, trans 84.
 HALL, J. O. 20 Sept 00. 218-220, V 15 No 2 Dec 00.
 13 Nov 01. 525-528, V 15 No 6 Dec 01.
 10 Sept 02. 387, 388, V 16 No 4 Dec 02.

- HASKELL, J. C. 8 Sept 97. 57-60, V 12 No 1 Sept 97.
 HILL, W. R., and Mrs. 13 Sept 99. 191, 192, V 14 No 2 Dec 99.
 HOLDEN, H. G. 8 June 92. 35, V 7 No 1 Sept 92.
 HOLMES, C. J. 12 June 89. 1, V 4 No 3 Sept 89.
 HOSLEY, Mayor. 15 June 87. 3, 4, V 2 No 1 Sept 87.
 HOWE, Hon C. H. 11 Mar 03. 232, 233, V 17 No 2 June 03.
 KENT, WILLARD. 14 Sept 98. 60-62, V 13 No 1 Sept 98.
 LYON, J. W. 21 June 83. 16-18, trans 83.
 MCGUIRE, J. K. 13 Sept 99. 176-179, V 14 No 2 Dec 99.
 MARSH, H. A. 14 June 93. 1, 2, V 8 No 1 Sept 93.
 MATTHEWS, NATHAN. 14 June 94. 1-5, V 9 No 1 Sept 94.
 MAYBERRY, G. S. 14 Jan 91. 102, 103, V 5 No 3 Mar 91.
 MERRILL, F. E. 14 June 03. 100-108, V 17 No 1 Mar 03.
 MILNE, PETER, Jr. 21 Apr 85. 201, 202, trans 85.
 NEVONS, HIRAM. 12 June 89. 3-5 V 4 No 1 Sept 89.
 NOYES, A. F. 10 June 91. 5, 6, V 6 No 1 Sept 91.
 O'BRIEN, HUGH. 21 Apr 85. 172, 199-201, trans 85.
 PHILBRICK, F. J. 14 Sept 98. 58, 59, V 13 No 1 Sept 98.
 PHILLIPS, H. M. 18 June 85. 12, 13, trans 85.
 ROBBINS, G. A. 13 June 88. 1, 2, V 3 No 1 Sept 88.
 ROBINSON, G. D. 21 Apr 85. 195-199, trans 85.
 ROTCH, MORGAN. 16 June 86. 3, 4, V 1 No 1 Sept 86.
 SHERMAN, W. B. 21 Apr 85. 209-211, trans 85.
 SIMIN, NICHOLAS. 8 Sept 97. 65, V 12 No 1 Sept 97.
 SIMMONS, W. A. 21 Apr 85. 202-205, trans 85.
 SPELLMAN, J. D. 19 Sept 00. 196, V 15 No 2 Dec 00.
 STACY, G. A. 15 June 94. 17, 18, V 9 No 1 Sept 94.
 11 Sept 95. 5-8, V 10 No 1 Sept 95.
 SULLIVAN, J. F. 8 June 92. 1, 2, V 7 No 1 Sept 92.
 WALKER, C. K. 14 Jan 03. 120, 121, V 17 No 1 Mar 03.
 WELLS, H. J. 21 Apr 85. 211, 212, trans 85.
 WOODBURY, Governor of Vermont. 11 Sept 95. 3, 4, V 10 No 1 Sept 95.

N. E. W. A Committees.

Executive committee.

- Recommend amendment of by-laws, article III of constitution.
 164, 165, trans 85.
 Recommend amendment of article VII, § 3, of constitution as to
 place of meeting. 71, 72, 74-76, V 13 No 1 Sept 98.
 Reports. 20, 21, trans 83.
 17, 18, trans 84.
 166, V 16 No 2 June 02.
 400, 401, V 16 No 4 Dec 02.
 234, V 17 No 2 June 03.
 300-302, V 17 No 3 Sept 03.
 430, V 17 No 4 Dec 03.

- Committee on badges. Reports. 18, V 2 No 1 Sept 87; 12, V 6 No 1 Sept 91; 9, 10, V 7 No 1 Sept 92; sample button exhibited, 9, V 4 No 1 Sept 89; adopted, 15, V 4 No 1 Sept 89.
- Committee on blue prints and sketches. Reports. 16-19, 55, V 1 No 1 Sept 86; 27-29, V 1 No 3 Mar 87; 22-25, V 2 No 1 Sept 87; 62, 86-91, V 2 No 1 Sept 87; 34, V 2 No 2 Dec 87; 17, 18, V 3 No 1 Sept 88; 9, V 4 No 1 Sept 89; 10, V 5 No 1 Sept 90; 9-13, V 6 No 1 Sept 91.
- Committee on cast-iron pipe: suggestions for report. 12-15, V 1 No 1 Sept 86; reports 91-93, V 2 No 1 Sept 87; 223, V 15 No 2 Dec 00; preliminary report on standard specifications, with disc, 85-98, disc 99-138, V 16 No 2 June 02, final report 330-334, tables and diags 335-366, disc 367-383, V 16 No 4 Dec 02; 84-96, V 17 No 1 Mar 03.
- Committee on election of officers. Committee to investigate methods of electing. 148, 149, V 5 No 4 June 91.
- Committee on entertainment. Report. 25, 26, trans 85.
- Committee on private fire protection. Apportionment of charges: disc, 406-431; city regulations of Providence, R I, San Francisco, Cal, and New Bedford, Mass, 438-440, V 15 No 5 Sept 01; report, 290-314; appendix, conditions, and conclusions, 315-329, V 16 No 4 Dec 02. Report, 425, 426, V 17 No 4 Dec 03.
- Committee on meeting. Appointed. 11, 12, V 7 No 1 Sept 92; report on place, 133-135, V 7 No 3 Mar 93; 115, 116, V 11 No 1 Sept 96; 71, 72, 74-76, V 13 No 1 Sept 98.
- Committee on pipe joints. Report on pipe joints and special castings. 13, V 3 No 1 Sept 88.
- Committee on water rates.
Uniform classification. 15, 16, V 1 No 1 Sept 86; 18, 32-42, disc 42-44, V 2 No 1 Sept 87; 9, 10, V 5 No 1 Sept 90; 39-43, disc 43-47, V 6 No 1 Sept 91.
- Committee on water works. Report on cause and prevention of waste of water. 27-29, disc 30-47, trans 83.
- Committee on water-works statistics.
Report. 123-140, trans 85; 9, 10, V 8 No 1 Sept 93; 127-134, V 9 No 2 Dec 94.
Report on uniformity of statistics: disc. 66-72, trans 84; 118-140, disc 141-148, trans 85; 9, 10, V 8 No 1 Sept 93.
Form adopted by N E W W A. 192, 193, V 15 No 2 Dec 00.
Report on uniformity (Sherman, C. W.). 450-452, V 15 No 5 Sept 01.
Report on uniformity of statistics. 51-58, disc 59-61, V 16 No 1 Mar 02.
Report. 263-266, disc 266-270, V 16 No 4 Dec 02.
- Committee to nominate officers appointed. 201, V 9 No 4 June 95.

NEW WA.

- Change of date of annual convention. 200, 201, V 9 No 4 June 95.
- Constitution and by-laws: pamphlet. 23 pp. 1882. Trans 82; 1-9, trans 83; 5-8, trans 84; 5-8, trans 85.
- Recommend amendment to article III. 164, 165, trans 85.
- Revision. 11, V 1 No 1 Sept 86; draft: disc; 207-215, V 15 No 2 Dec 00.
- Amendment of article VII, § 3. 71, 72, 74-76, V 13 No 1 Sept 98.
- Amendment as to place of meeting, proposed. 71, 72, disc 74-76, V 13 No 1 Sept 98.
- Constitution adopted 19 Sept 00. 8 pp after 298, V 15 No 3 Mar 01; 1-5, V 16 No 1 Mar 02.
- Consumption of water: statistics.
1886. 29, V 1 No 4 June 87.
1887. 29, V 2 No 4 June 88.
- 1888-92. After 225, V 7 No 4 June 93.
1893. 132, V 9 No 2 Dec 94.
1894. 136, V 10 No 2 Dec 95.
1895. 278, V 12 No 4 June 98.
1896. 286, V 12 No 4 June 98.
1897. 73, V 15 No 1 Sept 00.
1898. 83, V 15 No 1 Sept 00.
1899. 93, V 15 No 1 Sept 00.
1900. 384, 385, V 15 No 5 Sept 01.
1901. 238, 239, V 16 No 3 Sept 02.
1902. 252, 253, V 17 No 3 Sept 03.
- Consumption of water: statistics. Members' statements.
1894. 144-146, V 9 No 3 Mar 95.
- Distribution statistics. Tables, main and service pipes.
1886. Main, 30, V 1 No 4 June 87. Service, 31, V 1 No 4 June 87.
1887. Main, 30, V 2 No 4 June 88. Service, 31, V 2 No 4 June 88.
- 1888-92. Main, after 225, V 7 No 4 June 93. Service, after 225, V 7 No 4 June 93.
1893. Main, 133, V 9 No 2 Dec 94. Service 134, V 9 No 2 Dec 94.
1894. Main, 137, V 10 No 2 Dec 95. Service, 138, V 10 No 2 Dec 95.
1895. Main, 279, V 12 No 4 June 98. Service, 280, V 12 No 4 June 98.
1896. Main, 287, V 12 No 4 June 98. Service, 288, V 12 No 4 June 98.
1897. Main, 74, V 15 No 1 Sept 00. Service 75, V 15 No 1 Sept 00.
1898. Main, 84, V 15 No 1 Sept 00. Service, 85, V 15 No 1 Sept 00.
1899. Main, 94, V 15 No 1 Sept 00. Service, 95, V 15 No 1 Sept 00.
1900. Main, 386, 387, V 15 No 5 Sept 01. Service, 388, 389, V 15 No 5 Sept 01.

1901. Main, 240, 241, V 16 No 3 Sept 02. Service, 242, 243, V 16 No 3 Sept 02.
 1902. Main, 254, 255, V 17 No 3 Sept 03. Service, 256, 257, V 17 No 3 Sept 03.

Entertainments.

1883. June 22. Second annual convention, Worcester: visit to Chapmah Valve Co. 47, 48, trans 83.
 1884. June 19. Third annual excursion: to Tyng's island. 77, 78, trans 84.
 1885. June 19. Fourth annual entertainment, at Springfield. 153, trans 85.
 1885. Entertainment at meetings discussed. 166-169, trans 85.
 1885. Apr 21. Entertainments at joint meeting with Amer W W A. 178-220, trans 85.
 1886. June 16. Fifth annual meeting, New Bedford. 82, 83, V 1 No 1 Sept 86.
 1887. June 15. Sixth annual entertainment, Manchester, N H, Fletcher's island, Massabesic lake. 99, 100, V 2 No 1 Sept 87.
 1888. June 13. Seventh annual entertainment, excursion down Providence river. 20, V 3 No 1 Sept 88.
 1889. June 14. Eighth annual entertainment, Fall River, excursion to Newport. 26, V 4 No 1 Sept 89.
 1891. June 10. Tenth annual convention: ride to Hartford reservoirs. 14, V 6 No 1 Sept 91.
 1892. June 8. Eleventh annual entertainment, ascent of Mount Holyoke. 14, V 7 No 1 Sept 92.
 1893. June. Twelfth annual convention, Worcester, Lake Quinsigamond. 13, 14, V 8 No 1 Sept 93.
 1894. June 15. Thirteenth annual convention, Boston, Echo bridge, Newton, etc., and sail round Boston harbor. 18, 19, V 9 No 1 Sept 94.
 1895. Sept 11. Fourteenth annual convention, Burlington, Vt. Visits to Ausable chasm and Fort Ethan Allen. 28, V 10, No 1 Sept 95.
 1898. June 6. June field day: inspection of water system, New Bedford, Mass. 55-57, V 13 No 1 Sept 98.
 1899. June 14. June outing: Everett works, N E Gas and Coke Co. 92-96, V 14 No 1 Sept 99.
 1899. Sept 14. Eighteenth annual excursion, to Lake Skaneateles and Glen Haven, by steamer. 188, V 14 No 2 Dec 99.
 1900. Mar 14. Excursion to Brookline Water Works. 375, V 14 No 4 June 00.
 1900. June 13. Visit to Met Water Works at Spot pond and Fells reservoir, etc. 64, V 15 No 1 Sept 00.
 1902. Sept 12. Visit to Met Water Works. 394-398, V 16 No 4 Dec 02.

Exhibits.

19, 20, V 3 No 1 Sept 88; 27, V 4 No 1 Sept 89; 31, 32, V 5 No 1 Sept 90; 14, 15, V 7 No 1 Sept 92; 14, 15, V 8 No 1 Sept 93; 19, V 9 No 1 Sept 94; 28, 29, V 10 No 1 Sept 95; 116, 117, V 11 No 1 Sept 96; 71, V 12 No 1 Sept 97; 72, 73, V 13 No 1 Sept 98; 175, 176, V 14 No 2 Dec 99; 216, V 15 No 2 Dec 00; 452, 453, V 15 No 5 Sept 01; 393, V 16 No 4 Dec 02; 427, V 17 No 4 Dec 03.

Financial statements.

1883. 21-23, trans 83.
 1884. 19-21, trans 84.
 1885. 23, 24, trans 85.
 1886. 9-11, V 1 No 1 Sept 86.
 1887. 5, 6, V 2 No 1 Sept 87.
 1888. 5-7, V 3 No 1 Sept 88.
 1889. 6-8, V 4 No 1 Sept 89.
 1890. 6-8, V 5 No 1 Sept 90.
 1891. 7, 8, V 6 No 1 Sept 91.
 1892. 6-8, V 7 No 1 Sept 92.
 1893. 5-8, V 8 No 1 Sept 93.
 1894. 8-12, V 9 No 1 Sept 94.
 1895. 8-11, V 10 No 1 Sept 95.
 1896. 109-112, V 11 No 1 Sept 96.
 1897. 60-64, V 12 No 1 Sept 97.
 1898. 63-66, V 13 No 1 Sept 98.
 1899. 184-186, V 14 No 2 Dec 99.
 1900. 200-202, V 15 No 2 Dec 00.
 1900. 293-295, V 15 No 3 Mar 01.
 1901. 69-79, V 16 No 1 Mar 02.
 1902. 111-113, V 17 No 1 Mar 03.

Financial statistics. Form. 1902. 263, 264, V 16 No 4 Dec 02.

Financial statistics: tabulations.

1888-92. After 225, V 7 No 4 June 93.
 1893. 130, 131, V 9 No 2 Dec 94.
 1894. 134, 135, V 10 No 2 Dec 95.
 1895. 276, 277, V 12 No 4 June 98.
 1896. 284, 285, V 12 No 4 June 98.
 1897. 69-72, V 15 No 1 Sept 00.
 1898. 79-82, V 15 No 1 Sept 00.
 1899. 89-92, V 15 No 1 Sept 00.
 1900. 376-383, V 15 No 5 Sept 01.
 1901. 230-237, V 16 No 3 Sept 02.
 1902. 244-251, V 17 No 3 Sept 03.

Fire pipe committee. Private fire services. 201-202, V 17 No 2 June 03.

Headquarters of N E W W A.

- Discussion and recommendation of permanent headquarters. 11, V 6 No 1 Sept 91.
- Report of executive committee. 11-15, disc 18-24, V 10 No 1 Sept 95.
- Established at Tremont Temple, Boston. 148, V 10 No 3 Mar 96; ill 277, V 11 No 4 June 97.
- History of N E W W A.
- Twenty years after (inauguration). Coggeshall, R. C. P. 271-289, V 16 No 4 Dec 02.
- Portraits. 276-284, V 16 No 4 Dec 02.
- Journal of N E W W A.
- Advertisements in "Journal." 362, 363, V 15 No 4 June 01.
- Advertising agent's reports. 77-79, V 16 No 1 Mar 02.
- As quarterly; disc. 85, V 2 No 1 Sept 87.
- Editorial. 1, V 1 No 1 Sept 86.
- Index to be prepared. 400, 401, V 16 No 4 Dec 02.
- Journal editor. 362, 363, V 15 No 4 June 01.
- Report 1899-1900. 204-206, V 15 No 2 Dec 00; 1900-1901, 74-77, V 16 No 1 Mar 02; 1902, 114-117, V 17 No 1 Mar 03.
- Salary. 13, V 4 No 1 Sept 89.
- Meetings and conventions, Annual.
- 1st. Boston, 19 Apr 82. Proceedings. 23 pp pamphlet. Trans 82.
- 2d. Worcester, 21 June 83. Proceedings. 13-48, trans 83.
- 3d. Lowell, 19, 20 June 84. Proceedings. 11-78, trans 84.
- 4th. Springfield, 18, 19 June 85. Proceedings. 11-225, trans 85.
- 5th. New Bedford, 16 June 86. Proceedings. 3-86, V 1 No 1 Sept 86.
- 6th. Manchester, N H, 15-17 June 87. Proceedings. 3-100, V 2 No 1 Sept 87.
- 7th. Providence, R I, 13-15 June 88. Proceedings. 1-20, V 3 No 1 Sept 88.
- 8th. Fall River, 12-14 June 89. Proceedings. 1-64, V 4 No 1 Sept 89.
- 9th. Portland, Me, 11-13 June 90. Proceedings. 1-32, V 5 No 1 Sept 90.
- 10th. Hartford, Conn, 10-12 June 91. Proceedings. 1-17, V 6 No 1 Sept 91.
- 11th. Holyoke, 8-10 June 92. Proceedings. 1-14, V 7 No 1 Sept 92.
- 12th. Worcester, 14-16 June 93. Proceedings. 1-17, V 8 No 1 Sept 93.
- 13th. Boston, 14-16 June 94. Proceedings. 1-24, V 9 No 1 Sept 94.
- 14th. Boston, 12 June 95. Proceedings. 1, 2, V 10 No 1 Sept 95.
- Burlington, Vt. Annual convention. 11-13 Sept 95. Proceedings. 2-32, V 10 No 1 Sept 95.
- 15th. Lynn, 10-12 June 96. Proceedings. 99-120, V 11 No 1 Sept 96.

- 16th. Newport, R I. Annual convention. 8-10 Sept 97. Proceedings. 56-71, V 12 No 1 Sept 97.
- 17th. Portsmouth, N H. Annual convention. 14-16 Sept 98. Proceedings. 58-78, V 13 No 1 Sept 98.
- 18th. Syracuse, N Y. Annual convention. 13-15 Sept 99. Proceedings. 174-192, V 14 No 2 Dec 99.
- 19th. Boston, 13 June 00. Proceedings. 63, 64, V 15 No 1 Sept 00.
- Rutland, Vt. Annual convention. 19, 20 Sept 00. Proceedings. 194-220, V 15 No 2 Dec 00.
- 20th. Annual meeting. 9 Jan 01. 290-296, V 15 No 3 Mar 01.
- Portland, Me. Annual convention. 18-20 Sept 01. Proceedings. 443-454, V 15 No 5 Sept 01.
- 21st. Annual meeting. 8 Jan 02. 65-81, V 16 No 1 Mar 02.
- 21st. Boston. Annual convention. 10-12 Sept 02. Photo group. 384. Proceedings. 384-398, V 16 No 4 Dec 02.
- 22d. Annual meeting. 14 Jan 03. Proceedings. 99-121, V 17 No 1 Mar 03.
- 22d. Montreal, 9-11 Sept 03. Annual convention. Proceedings. 418-429, V 17 No 4 Dec 03.
- Meetings: general.
- 1882, Oct 11. Salem, Essex House. Proceedings. 11-13, trans 83.
- 1883, Sept 19. Pawtucket, R I. Proceedings. 49-52, trans 83.
- 1884, Sept 24. Newton. Proceedings. 79-82, trans 84.
- 1885, Jan 29. Boston. Proceedings. 160-169, trans 85.
- 1886, Sept 15. Lawrence. Quarterly meeting: proceedings. 3-28, V 1 No 2 Dec 86.
- Dec 7. Boston. Quarterly meeting: proceedings. 3, 4, V 1 No 3 Mar 87.
- 1887, Mar 9. Boston. Quarterly meeting: proceedings. 18-26, V 1 No 4 June 87.
- Dec 14. Boston. Quarterly meeting: proceedings. 3-29, V 2 No 3 Mar 88.
- 1888, Jan 11. Boston. Adjourned meeting: proceedings. 29-53, V 2 No 3 Mar 88.
- Feb 15. Boston. Adjourned meeting: proceedings. 3-6, V 2 No 4 June 88.
- Mar 14. Boston. Quarterly meeting: proceedings. 6-26, V 2 No 4 June 88.
- Sept 12. Cambridge. Quarterly meeting: proceedings. 67-98, V 3 No 2 Dec 88.
- Dec 12. Boston. Quarterly meeting: proceedings. 101-103, V 3 No 3 Mar 89.
- 1889, Jan 16. Boston. Adjourned meeting: proceedings. 103-142, V 3 No 3 Mar 89.

- Feb 13. Boston. Adjourned meeting: proceedings. 145-147,
V 3 No 4 June 89.
- Mar 13. Boston. Quarterly meeting: proceedings. 147-153,
V 3 No 4 June 89.
- Dec 11. Boston. Quarterly meeting: proceedings. 65-68, V 4
No 2 Dec 89.
- 1890, Jan 8. Boston. Proceedings. 93-95, V 4 No 3 Mar 90.
- Feb 12. Boston. Proceedings. 173-175, V 4 No 4 June 90.
- Mar 12. Boston. Quarterly meeting: proceedings. 175-178,
V 4 No 4 June 90.
- Dec 10. Boston. Quarterly meeting: proceedings. 71-82,
V 5 No 2 Dec 90.
- 1891, Jan 14. Boston. Proceedings. 101-108, V 5 No 3 Mar 91.
- Feb 11. Boston. Quarterly meeting: proceedings. 109-115,
V 5 No 3 Mar 91.
- Mar 11. Boston. Proceedings. 145-149, V 5 No 4 June 91.
- Dec 9. Boston. Quarterly meeting: proceedings. 99, 100.
V 6 No 3 Mar 92.
- 1892, Jan 13. Boston. Adjourned meeting: proceedings. 101, 102,
V 6 No 3 Mar 92.
- Feb 10. Boston. Adjourned meeting: proceedings. 147-149,
V 6 No 4 June 92.
- Mar 9. Boston. Quarterly meeting: proceedings. 150, 151,
Vol 6 No 4 June 92.
- Dec 14. Boston. Quarterly meeting: proceedings. 131-136,
V 7 No 3 Mar 93.
- 1893, Jan 11. Boston. Adjourned meeting: proceedings. 136-138,
V 7 No 3 Mar 93.
- Feb 8. Boston. Adjourned meeting: proceedings. 181-185,
V 7 No 4 June 93.
- Mar 8. Boston. Quarterly meeting: proceeding. 184-186,
V 7 No 4 June 93.
- Dec 13. Boston. Quarterly meeting: proceedings. 109-111,
V 8 No 3 Mar 94.
- 1894, Jan 10. Boston. Adjourned meeting: proceedings. 111, 112,
V 8 No 3 Mar 94.
- Feb 16. Boston. Adjourned meeting: proceedings. 161-163,
V 8 No 4 June 94.
- Mar 14. Boston. Quarterly meeting: proceedings. 163-166,
V 8 No 4 June 94.
- Dec 12. Boston. Quarterly meeting: proceedings. 135-139,
V 9 No 3 Mar 95.
- 1895, Jan 9. Boston. Adjourned meeting: proceedings. 139-146,
V 9 No 3 Mar 95.
- Feb 13. Boston. Adjourned meeting: proceedings. 191-198,
V 9 No 4 June 95.

- Mar 13. Boston. Quarterly meeting: proceedings. 198-201,
V 9 No 4 June 95.
- June 12. Boston. Annual meeting: proceedings. 1-2, V 10
No 1 Sept 95.
- Dec 11. Boston. Quarterly meeting: proceedings. 141-146,
V 10 No 3 Mar 96.
- 1896, Jan 8. Boston. Adjourned meeting: proceedings. 146-149,
V 10 No 3 Mar 96.
- Feb 12. Boston. Adjourned meeting: proceedings. 287-289,
V 10 No 4 June 96.
- Mar 11. Boston. Quarterly meeting: proceedings. 289-293,
V 10 No 4 June 96.
- Dec 9. Boston. Quarterly meeting: proceedings. 266, 267,
V 11 No 3 Mar 97.
- 1897, Jan 13. Boston. Adjourned meeting: proceedings. 268-270,
V 11 No 3 Mar 97.
- Feb 10. Boston. Adjourned meeting: proceedings. 271-274,
V 11 No 3 Mar 97.
- Mar 10. Boston. Quarterly meeting: proceedings. 358-360,
V 11 No 4 June 97.
- Dec 8. Boston. Quarterly meeting: proceedings. 204, 205,
V 12 No 3 Mar 98.
- 1898, Jan 12. Boston. Adjourned meeting: proceedings. 206, 207,
V 12 No 3 Mar 98.
- Feb 9. Boston. Adjourned meeting: proceedings. 289, 290,
V 12 No 4 June 98.
- Mar 9. Boston. Quarterly meeting: proceedings. 290, 291.
V 12 No 4 June 98.
- Dec 14. Boston. Quarterly meeting: proceedings. 242-244,
V 13 No 3 Mar 99.
- 1899, Jan 11. Boston. Adjourned meeting: proceedings. 345-348,
V 13 No 4 June 99.
- Feb 8. Boston. Adjourned meeting: proceedings. 88, 89,
V 14 No 1 Sept 99.
- Mar 8. Boston. Quarterly meeting: proceedings. 89-92,
V 14 No 1 Sept 99.
- Dec 13. Boston. Quarterly meeting: proceedings. 286, 287,
V 14 No 3 Mar 00.
- 1900, Jan 10. Boston. Adjourned meeting: proceedings. 287-289,
V 14 No 3 Mar 00.
- Feb 14. Boston. Adjourned meeting: proceedings. 289-290,
V 14 No 3 Mar 00.
- Mar 14. Boston. Quarterly meeting: proceedings. 373-375.
V 14 No 4 June 00.
- June 13. Boston. Annual meeting: proceedings. 63-64,
V 15 No 1 Sept 00.

- Nov 14. Boston. Proceedings. 221, 222, V 15 No 2 Dec 00.
 Dec 12. Boston. Proceedings. 288, 289, V 15 No 3 Mar 01.
 1901, Jan 9. Boston. Annual meeting: proceedings. 290-296,
 V 15 No 3 Mar 01.
 Feb 13. Boston. Proceedings. 297, 298, V 15 No 3 Mar 01.
 Mar 13. Boston. Proceedings 360-363, V 15 No 4 June 01.
 June 12. Somerville. Proceedings. 441-443, V 15 No 5
 Sept 01.
 Dec 11. Boston. Proceedings. 62-64, V 16 No 1 Mar 02.
 1902, Jan 8. Boston. Annual meeting: proceedings. 65-81, V 16
 No 1 Mar 02.
 Feb 12. Boston. Proceedings. 82-84, V 16 No 1 Mar 02.
 Mar 12. Boston. Proceedings. 164, 165, V 16 No 2 June 02.
 June 25. Boston. Proceedings. 244-246, V 16 No 3 Sept 02.
 Nov 12. Boston. Proceedings. 389-400. V 16 No 4 Dec 02.

Membership roll.

1882. Pamphlet, 23 pp, trans 83.
 1883. 53, 54, trans 83. 1884. 85, 86, trans 84.
 1885. 13-16, trans 85. 1 Jan 86. 232-235, trans 85.
 30 Jan 86. 7-10, trans 86. 87-91, V 1 No 1 Sept 86.
 June 87. 104-109, V 2 No 1 Sept 87. 1 Sept 88. 16-page pamphlet,
 after 66, V 3 No 1 Sept 88. Corrections to Sept 88. After 100,
 V 3 No 2 Dec 88. 1 Mar 89, 16 pp after 143, V 3 No 3 Mar 89.
 1889. 22 pp after 64, V 4 No 1 Sept 89. 1 Sept 90, 24 pp after 69,
 V 5 No 1 Sept 90. 1 Apr 91, 24 pp after 144, V 5 No 3 Mar 91.
 1 Sept 91, 24 pp after 188, V 6 No 4 June 92. 1 May 92, with roll
 of, 1 Sept 91, after 188, V 6 No 4 June 92. 10 Mar 93, 24 pp (8-17
 missing) after 180, V 7 No 3 Mar 93. June 94. 28 pp after 195.
 V 8 No 4 June 94. June 95. 31 pp after 248, V 9 No 4 June 95.
 1 Sept 97, 32 pp after 72, V 12 No 1 Sept 97. 1 Sept 98, 33 pp
 after 156, V 13 No 2 Dec 98. 1 Sept 99, 32 pp after 194, V 14
 No 2 Dec 99. Mar 01, 48 pp after 298, V 15 No 3 Mar 01. 1 Feb
 02, 7-31 pp.

Geographical distribution of members. 32-35, V 16 No 1 Mar 02.

Members — Obituary.

- Ball, Phinehas. 19 Dec 94. 189, V 9 No 3 Mar 95.
 Barbour, William S. 24 Feb 89. 143, V 3 No 3 Mar 89, resolution
 on death; 148, 149, V 3 No 4 June 89.
 Batchelder, George E. 12 Mar 99. 349, V 13 No 4 June 99.
 Battles, James Monroe. 8 July 01. 455, V 15 No 5 Sept 01.
 Bickford, Nathan B. 24 June 99. 200, V 15 No 2 Dec 00.
 Boyce, W. C. 15 July 89. 65, V 4 No 1 Sept 89.
 Brainerd, C. M. 25 Dec 93. 195, V 8 No 4 June 94.
 Brush, Charles B. 3 June 97. 72, V 12 No 1 Sept 97.
 Chaffee, Fred I. 28 Nov 95. 140, V 10 No 2 Dec 95.
 Chandler, Henry. 10 Oct 00. 224, V 15 No 2 Dec 00.

- Clark, Ezra. 26 Sept 96. 275, V 11 No 3 Mar 97.
 Conant, Henry W. 18 Nov 99. 19, V 14 No 2 Dec 99; 200, V 15
 No 2 Dec 00.
 Coolidge, Samuel S. 9 Mar 89. 209, V 3 No 4 June 89.
 Coryell, Martin. 30 Nov 86. 101, V 2 No 1 Sept 87.
 Cotton, J. Warren. 30 July 84. 83, trans 84.
 Crehore, Dr Charles F. 7 Nov 93. 108, V 8 No 2 Dec 93.
 Crilly, Patrick F. 25 Mar 01. 364, V 15 No 4 June 01.
 Davidson, James. 4 Dec 91. 188, V 6 No 4 June 92.
 Decker, John H. 8 Mar 01. 455, V 15 No 5 Sept 01.
 Dennett, Nathaniel 21 Feb 00. 375, V 14 No 4 June 00; 200, V 15
 No 2 Dec 00.
 Dixon, William. 12 Sept 93. 108, V 8 No 2 Dec 93.
 Doherty, Cornelius. F. 17 Nov 95. 140, V 10 No 2 Dec 95.
 Downey, William. 1 Oct 01. 247, V 16 No 3 Sept 02.
 Dyer, Charles R. 12 Sept 93. 195, V 8 No 4 Dec 94.
 Eaton, Horace L. 23 Nov 95. 139, V 10 No 2 Dec 95.
 Fuller, Frank E. 1 Aug 02. 247, V 16 No 3 Sept 02.
 Gale, James M. 7 Sept 03. 303, V 17 No 3 Sept 03.
 Garrett, Jesse. 27 Apr 99. 349, 350, V 13 No 4 June 99.
 Gow, Robert M. 6 June 92. 88, V 7 No 1 Sept 92.
 Granniss, Sherman E. 10 Aug 93. 53, V 8 No 1 Sept 93.
 Grush, Benjamin. 3 May 91. 64, V 6 No 1 Sept 91.
 Hancock, Joseph C. 12 July 02. 247, V 16 No 3 Sept 02.
 Harlow, Mellen S. 11 Dec 95. 298, V 15 No 3 Mar 01.
 Harrington, John L. 16 Aug 95. 76, V 10 No 1 Sept 95.
 Haskell, John C. 12 June 00. 200, V 15 No 2 Dec 00.
 Hawes, William M. 16 Feb 98. 292, V 12 No 4 June 98.
 Hodge, Thomas A. 16 Dec 87. 36, V 2 No 3 Mar 88.
 Holden, Andrew. n. d. 200, V 15 No 2 Dec 00.
 Horton, Sylvanus. 19 Apr 88. 27, V 2 No 4 June 88.
 Hotchkin, George A. 6 Oct 02. 402, V 16 No 4 Dec 02.
 Jenkins, George S. 12 Nov 00. 224, V 15 No 2 Dec 00.
 Kempton, David Batchelder. 4 Mar 99. 349, 350, V 13 No 4 June 99.
 Laing, William H. 5 Aug 01. 456, V 15 No 5 Sept 01.
 Leach, Samuel B. 28 Jan 92. 145, V 6 No 3 Mar 92.
 LeBaron, Eugene P. 1 Dec 93. 160, V 8 No 3 Mar 94.
 Linsley, Dr J. H. 17 Feb 01. 364, V 15 No 4 June 01.
 Locke, Augustus W. 14 May 93. 227, V 7 No 4 June 93.
 Lockwood, Joseph A. 24 Aug 97. 72, V 12 No 1 Sept 97.
 McClallan, William C. 15 Sept 88. 99, V 3 No 2 Dec 88.
 McLaughlin, Thomas H. 17 Dec 93. 195, V 8 No 4 June 94.
 Martin, Cyrus B. 2 Apr 02. 125, V 17 No 1 Mar 03.
 Martin, Robert K. 24 Nov 93. 160, V 8 No 3 Mar 94.
 Morse, James W. 23 Sept 99. 193, V 14 No 2 Dec 99; 200, V 15
 No 2 Dec 00.

- Murphy, Charles F. 6 Apr 99. 193, V 14 No 2 Dec 99.
 Nason, William E. 10 Oct 96. 275, V 11 No 3 Mar 97.
 Nevons, Hiram. 27 Mar 94. 63, V 9 No 1 Sept 94.
 Nichols, Prof William Ripley. 14 July 86. 27, 28, V 1 No 2 Dec 86.
 Noyes, Albert F. 12 Oct 96. Portrait. 274, 275, V 11 No 3 Mar 97.
 Osborn, Weaver. 3 Feb 94. 195, V 8 No 4 June 94.
 Parks, Charles F. 21 Apr 03. 303, V 17 No 3 Sept 03.
 Pengilly, Lewis H. 22 Sept 88. 99, V 3 No 2 Dec 88.
 Reed, Wilmer. Nov 96. 276, V 11 No 3 Mar 97.
 Rogers, Henry W. 15 Apr 01. 365, V 15 No 4 June 01.
 Salisbury, Arnold H. 5 July 01. 456, V 15 No 5 Sept 01.
 Seymour, Charles W. S. 16 Oct 93. 108, V 8 No 2 Dec 93.
 Sprague, Phineas. 14 Sept 87. 35, V 2 No 2 Dec 87.
 Stanwood, James Hugh. 25 Mar 96. 275, V 11 No 3 Mar 97.
 Stoddard, Samuel G., Jr. 21 Aug 01. 457, V 15 No 5 Sept 01.
 Taylor, William. D. 2 Jan 94. 195, V 8 No 4 June 94.
 Tidd, Marshall M. 20 Aug 95. 76, V 10 No 1 Sept 95.
 Upton, Albert F. 8 June 88. 99, V 3 No 2 Dec 88.
 Weld, F. Floyd. 28 June 90. V 6 No 1 Sept 91.
 Whidden, Hosea F. 31 Jan 88. 36, V 3 No 2 Mar 88.
 Winship, Horace B. 8 Nov 99. 193, V 14 No 2 Dec 99; 200, V 15
 No 2 Dec 00.
 Yates, Richard R. 10 Sept 96. 72, V 12 No 1 Sept 99.
- Officers: election.
 1883-4. 24, 25, trans 83. 1884-5. 22-27, trans 84.
 1885-6. 69, 70, trans 85. 1886-7. 34, V 1 No 1 Sept 86
 1887-8. 44, 45, V 2 No 1 Sept 87. 1888-9. 16, 17, V 3 No 1 Sept 88.
 1889-90. 14, V 4 No 1 Sept 89. 1890-91. 14, 15, V 5 No 1 Sept 90.
 1891-2. 10, V 6 No 1 Sept 91. 1892-3. 11, V 7 No 1 Sept 92.
 1893-4. 11, 12, V 8 No 1 Sept 93. 1894-5. 16, V 9 No 1 Sept 94.
 1895-6. 16, 17, V 10 No 1 Sept 95. 1896-7. 114, 115, V 11 No 1 Sept 96
 1897-8. 67, V 12 No 1 Sept 97. 1898-9. 76, V 13 No 1 Sept 98.
 1899-1900. 188, 189, V 14 No 2 Dec 99.
 1901. 295, 296, V 15 No 3 Mar 01. 1902. 79, 80, V 16 No 1 Mar 02.
 1903. 119, V 17 No 1 Mar 03.
 List of officers, 1902. 6, V 16 No 1 Mar 02
- Presentation of gavel by Amer W W A, 12 June 99. 6, V 4 No 1 Sept
 99.
- Portraits.
 Coggeshall, Robert C. P. 282, V 16 No 4 Dec 02.
 Ellis, George A. 280, V 16 No 4 Dec 02.
 Hall, Frank E. 278, V 16 No 4 Dec 02.
 Lyon, James W. 256, V 16 No 4 Dec 02.
 Merrill, Frank E. 100, V 17 No 1 Mar 03.
 Noyes, Albert F. 274, 275, V 11 No 3 Mar 97.
 Rogers, Henry W. 284, V 16 No 4 Dec 02.

Walker, Charles K., Front. V 17 No 1 Mar 03.

Presidents.

Past presidents, after 298, V 15 No 3 Mar 01; 6, V 16 No 1 Mar 02.

Past presidents 1882-1887, portraits. *See* Portraits.

Past presidents 1882-1889. 194, V 14 No 2 Dec 99.

Secretary: salary. 11, V 1 No 1 Sept 86, disc 45-48, V 2 No 1 Sept 87.

Secretary's annual reports.

1882. 21, 22, trans 83.

1884. 19, 20, trans 84.

1885. 23, trans 85.

1886. 11, V 1 No 1 Sept 86.

1887. 5, V 2 No 1 Sept 87.

1888. 5, V 3 No 1 Sept 88.

1889. 5, 6, V 4 No 1 Sept 89.

1890. 4, 5, V 5 No 1 Sept 90.

1891. 6, 7, V 6 No 1 Sept 91.

1892. 6, V 7 No 1 Sept 92.

1893. 5, 6, V 8 No 1 Sept 93.

1894. 8-10, V 9 No 1 Sept 94.

1895. 10, 11, V 10 No 1 Sept 95.

1896. 109, 110, V 11 No 1 Sept 96.

1897. 63, 64, V 12 No 1 Sept 97.

1898. 65, 66, V 13 No 1 Sept 98.

1899. 187, V 14 No 2 Dec 99.

1900. 291, 292, V 15 No 3 Mar 01.

1901. 72-74, V 16 No 1 Mar 02.

1902. 108-110, V 17 No 1 Mar 03.

Coggeshall, R. C. P. Resignation, 9 Jan 95. 141-144, V 9 No 3 Mar 95.

Table of presidents, membership, annual conventions, financial condition. 102, V 17 No 1 Mar 03.

Tests of articles of commerce. 27, 28, V 1 No 4 June 87; 109-111, disc 111-116, V 10 No 2 Dec 95. *See* Herschel, Clemens.

Water-works statistics.

1886. 28-31, V 1 No 4 June 87.

1887. 28-31, V 2 No 4 June 88

1888-92. 225 and tables, V 7

(comp by Willard Kent).

No 4 June 93.

1893. 127-134, V 9 No 2 Dec 94.

1894. 131-138, V 10 No 2 Dec 95.

1895. 273-280, V 12 No 4 June 98.

1896. 281-288, V 12 No 4 June 98.

1897. 66-75, V 15 No 1 Sept 00.

1898. 76-85, V 15 No 1 Sept 00.

1899. 86-95, V 15 No 1 Sept 00.

1900. 367-389, V 15 No 5 Sept 01.

1901. 225-243, V 16 No 3 Sept 02.

1902. 235-257, V 17, No 3 Sept 03.

New Haven Water Works, Conn. Dam at Woodbridge. TAYLOR, L. A.

Diags. 51-55, disc 55, 56, V 6 No 1 Sept 91.

New London Water Works, Conn.

RICHARDS, W. H. High-service system. 148-151, V 7 No 3 Mar 93.

Nine hundred feet, 24-inch cypress stave pipe: described. 287, V 13 No 4 June 99.

New Orleans water purification.

WESTON, R. S. Turbidity determinations. 27-31, V 17 No 1 Mar 03.

Water supply. The water supply and its improvement. 157-171, disc 171-173, V 17 No 3 June 03.

Newark Water Works, N J. E Jersey Water Co. HERSCHEL, CLEMENS, and others. 18-39, V 8 No 1 Sept 93.

Newport Water Works, N H, Construction. TAYLOR, L. A. 145-149, disc 149-152, V 12 No 3 Mar 98.

Newton Water Works, Mass.

COFFIN, F. C. Covered reservoir: description. 254, V 14 No 3 Mar 01.

HYDE, H. N. City street main flushing. 80, 81, trans 85.

Nichols, Prof William Ripley. Died, 14 July 86. Obituary 27, 28, V 1 No 2 Dec 86.

Nicol prism in turbidimeter, described. ANTHONY, C., Jr. 258, 259, disc 261, 262, V 16 No 4 Dec 02.

Night work. GARDNER, E. P. Wells light for. 168-170, V 7 No 3 Mar 93.

Niles, Prof W. H.

Causes of rainfall. 345-348, V 15 No 4 June 01.

Secular and local variations of weather and climate as affecting water supply. 74, 75, disc 75-78, V 5 No 2 Dec 90.

Norfolk, Va, filters. WESTON, E. B. Ill. 346, 347, V 14 No 4 June 00.

Norias: water elevators, described. 35, V 1 No 1 Sept 86.

Northrop, Frank L. Filter at Milford Water Works, Mass. 262-264, V 10 No 4 June 96.

Novel way of placing a bridge in position. ALLEN, C. A. 197, 198, V 3 No 4 June 89.

Noyes, Albert F. Pres N E W W A. Portrait 274, 275, V 11 No 3 Mar 97.

Address to N E W W A, 10 June 91, Hartford, Conn. 5, 6, V 6 No 1 Sept 91.

Consumption of water: collected statistics. 123, 124, V 9 No 2 Dec 94.

Covered reservoirs. 124, V 8 No 3 Mar 94.

Disc meters. 103, 104, V 10 No 2 Dec 95.

Driven wells. 80, 81, V 1 No 1 Sept 86.

Driven wells as a source of water supply. 19-26, V 1 No 4 June 87.

Excavating in quicksand: experience. 218, 219, disc 219, 220, V 4 No 4 June 90.

Iron used in pipe making. 55, 57-59, V 11 No 1 Sept 96.

Licensing plumbers: disc. 27, V 1 No 1 Sept 86.

Mass Met water supplies. Diags. 117-129, V 10 No 2 Dec 95.

Pipes for driven wells. 142, 143, V 5 No 3 Dec 91.

Public and private water works. 24, V 4 No 1 Sept 89.

Ratio of pumping capacity to maximum consumption: disc. 112, 113, V 3 No 3 Mar 89.

Reservoir embankment construction. 138-140, V 8 No 3 Mar 94.

Specifications for water works. 174-176, V 6 No 4 June 92.

Tanks for kitchen boilers and water closets. 62-64, trans 85.

Water hammer. 72-81, V 1 No 1 Sept 86.

Water supply sources. 129, 130, V 6 No 3 Mar 92.

Weights of cast-iron pipe. Diags. 154-159, disc 28-31, trans 85.

Died 12 Oct 96. Obituary 275, 276, V 11 No 3 Mar 97.

Nozzles.

As water meters. 100-105, V 4 No 3 Mar 89.

FREEMAN, J. R. For fire hose. 51-54, V 7 No 1 Sept 92.

Various kinds. Diags and tables. 120-161, V 4 No 3 Mar 90.

GERHARD, W. P. For fire protection and sprinklers for theater fire service. 84-89, V 9 No 2 Dec 94.

Nuebling, Emil L., and others. Discussion of report of N E W W A, Com on cast-iron pipe. 99-138, V 16 No 2 June 02.

Nye, Joseph K. Fairhaven Water Works. 175-180, disc 180-182, V 8 No 4 June 94.

Oak Ridge gate house, E Jersey Water Co. HERSCHEL, CLEMENS. Diag. 24-40, V 8 No 1 Sept 93.

Obituary N E W W A. See N E W W A, Obituary.

O'Brien, Mayor Hugh, Boston.

Address to N E W W A, 21 Ap 85. 172, trans 85.

Remarks at dinner of Amer W W A and N E W W A, 21 Ap 85. 199-201, trans 85.

Odor and color of surface water.

DROWN, Prof T. M. (Chemical aspect.) 3-15, disc 15-29, V 2 No 3 Mar 88.

FORBES, F. F. And taste imparted to water by algæ and infusoria. 90-96, disc 96, 97, V 6 No 2 Dec 91.

By chara fragilis. 252-254, V 10, No 4 June 96.

SEDGWICK, Prof W. T. And taste in water supplies (unpleasant). 54-64, V 14 No 1 Sept 99.

Officers of N E W W A. See N E W W A, Officers.

Offsets.

BRACKETT, DEXTER. Diags and dimensions. Plate IX, 78, V 8 No 2 Dec 93.

N E W W A, Com on cast-iron pipe. Table. 94, V 17 No 1 Mar 03.

Oil, gas, and gasoline pumping engines. COFFIN, F. C. Diag. 206-217, V 13 No 3 Mar 99.

Olmsted, Frederick Law, jr. Landscape problems in the improvement of Spot pond reservoir (Met Water Works) Middlesex Fells. Ills. 272-287, V 15 No 3 Mar 01.

Oporto. Sand filters. SEDGWICK, Prof W. T. Description. 115, V 7 No 2 Dec '92.

Organisms.

Algæ.

FORBES, F. F. Chara fragilis in reservoir. 252-254, V 10 No 4 June 96.

Algæ growth in reservoirs and ponds. 196-204, disc 204-210, V 4 No 4 June 90.

Taste and odor imparted to water by some algæ and infusoria. 90-96, disc 96, 97, V 6 No 2 Dec 91.

HASKELL, J. C. Extermination of algæ by kerosene fire on pond bottom, Lynn, Mass. 64, V 10 No 1 Sept 95.

HILL, W. R. Method of removing organisms from water in distributing reservoir of Syracuse, N Y. Ill. 213-216, disc 216-229, V 14 No 3 Mar 00.

Anabæna in water.

WESTON, R. S., and others. 27, V 13 No 1 Sept 98.

Asterionella.

FORBES, F. F. Effect on water. 92, 93, V 6 No 2 Dec 91.

In Brookline and Waltham reservoirs. 25, 26, V 11 No 1 Sept 96.

WHIPPLE, G. C., and JACKSON, D. D. Biology, chemistry, and effect on water supplies. 1-23, disc 23-25, V 14 No 1 Sept 99.

In deep and shallow ponds, distribution chart. 214, V 9 No 3 June 95.

Chara fragilis.

FORBES, F. F. Appearance in reservoir of public water supply. 252-254, V 10 No 4 June 96.

Chlorophyceæ: green algæ in surface water.

WHIPPLE, G. C. 212, V 9 No 4 June 95.

Cristatella in storage reservoir, Henderson, N C.

WESTON, R. S. Map and diag. 20-26, disc 27-29, V 13 No 1 Sept 98.

Diatoms.

WHIPPLE, G. C. Relation of light to growth of. Diags and tables 1-24, disc 25, 26, V 11 No 1 Sept 96.

WHIPPLE, G. C., and JACKSON, D. D. Asterionella, effect on water supplies. Diags. 1-23, disc 23-25, V 14, No 1 Sept 99.

Infusoria.

FORBES, F. F. Taste and odor imparted to water by. 90-96, disc 96, 97, V 6 No 2 Dec 91.

HOLLIS, F. S., and PARKER, H. N. Chlamydomonas in Spot pond (Met Water Works). Diags. 26-29, disc 30, 31, V 14 No 1 Sept 99.

WHIPPLE, G. C. In surface waters. 215, 216, V 9 No 4 June 95.

Raphidomonas in (Lynn) water. Ill. 348-357, V 11 No 4 June 97.

Raphidomonas (Infusorian) in Lynn water.

WHIPPLE, G. C. Ills. 348-357, V 11 No 4 June 97.

Uroglæna.

GOODNOUGH, X. H. Examination of public water supplies. 70-78, disc 78-81, V 14 No 1 Sept 99.

Uvella, the worst infusorian in water.

FORBES, F. F. 91, 92, V 6 No 2 Dec 91.

HOLLIS, F. S. Removed from water. 221-223, disc 223-229, V 14 No 3 Mar 00.

SEDGWICK, Prof W. T. Causing unpleasant odors and tastes in water supplies. 54-64, V 14 No 1 Sept 99.

WHIPPLE, G. C. Growth in water pipes. Diags and tables. 1-17, disc 17-19, V 12 No 1 Sept 97.

Osborn, Weaver. Died 3 Feb 94. Obituary 195, V 8 No 4 June 94.

Oxidation of water. BABCOCK, S. E. 38-40, V 3 No 1 Sept 98.

Ozonization of water. SOPER, Dr G. A. 1-11, disc 11-19, V 15 No 1 Sept 00.

- Pacific slope.** ALLIS, S. M. Erosion, and its effects. 158-161, V 3 No 4 June 89.
- Packing pipes for protection from freezing.** GOW, F. W., and others. 196-203, V 12 No 3 Mar 98.
- Packing for water gates.** Disc 92-94, trans 85. 71, V 1 No 1 Sept 86.
- Paper mill wastes polluting streams.** CLARK, H. W. 500-510, disc 510-513, V 15 No 6 Dec 01.
- Paris covered reservoirs.** SWAN, C. H. 51-53, V 3 No 1 Sept 88.
- Parker, F. H.**
Corrosion of pipes. 41, trans 85.
High-service motor, Burlington, Vt. Diag. 63-66, disc 66-68, V 2 No 1 Sept 87.
Setting hydrants, St. Paul, Minn. 11, 12, V 4 No 1 Sept 89.
Water tanks: disc. 28, V 2 No 1 Sept 87.
- Parker, Horatio N. (with F. S. Hollis).**
Chlamydomonas in Spot pond (Met Water Works). Diags. 26-29, disc 30, 31, V 14 No 1 Sept 99.
Examination of public water supplies. 80, 81, V 14 No 1 Sept 99.
Removing organisms from water: disc. 222-228, V 14 No 3 Mar 00.
- Parks, Charles F.** Died 21 April 03. Obituary 303, V 17 No 3 Sept 03.
- Pawtucket Water Works, R. I.**
DEAN, F. W. Pumping engine. Ill. 91, 92, V 8 No 2 Dec 93.
ROGERS, H. W. Filter cleaning, 20 Nov 83. 55-57, trans 84.
- Payment for fire protection.** FOSTER, JOEL. 270-272, V 12 No 4 June 98.
- Pengilly, Lewis H.** Died 22 Sept 88. Obituary 99, V 3 No 2 Dec 88.
- Pennichuck Water Works, Nashua, N H.**
HOLDEN, H. G. Service box. Ill. 310, V 15 No 4 June 01.
The water supply of Nashua, N H. 249-255, V 16 No 4 Dec 02.
- Penstocks (Iron and steel).** HALE, R. A. Tubercles in. Diag. 244-251, V 10 No 4 Dec 96.
- Peoria Water Co.** KNUDSON, A. A. Pipes showing electrolytic pitting. 250, V 15 No 3 Mar 01.
- Perry, Fred G.** Recording pressure gages, use and advantage. 255-257, disc 257-261, V 10 No 4 June 96.
- Philbrick, F. J.** Address to N E W W A, seventeenth annual meeting, Portsmouth, N H. 58, 59, V 13 No 1 Sept 98.
- Phillips, Mayor H. M.** Address to N E W W A, 18 June 85. 12, 13, trans 85.
- Physical properties of water.** HAZEN, ALLEN. 21-27, disc 27-31, V 17 No 1 Mar 03.
- Piezometers.**
FREEMAN, J. R. 98, 99, V 4 No 3 Mar 90.
FRENCH, E. V. Diags. 78, V 12 No 2 Dec 97.
KIMBALL, F. C. 310, V 17 No 4 Dec 03.
- Pipe cleaning.** BRACKETT, DEXTER. Scrapers for pipe cleaning. 4, V 1 No 3 Mar 87.

Pipe laying. See Laying of pipe.

Pipe system of Malden, Mass. ALLIS, S. M. 164, 165, V 5 No 4 June 91.

Pipe trenches.

COGGESHALL, R. C. P. Portable platform to aid in excavating. 125, 126, V 9 No 2 Dec 94.

FULLER, F. L. Back filling, ramming and tamping. 171-173, V 6 No 4 June 92.

GOWING, E. H. Back filling. 173-177, disc 177-188, V 12 No 3 Mar 98.

HAMMATT, E. A. W. Back filling. 160-165, disc 166-172, V 12 No 3 Mar 98.

MCCLINTOCK, W. E. Water pipe trenches *v* good roads. 71-77, V 8 No 2 Dec 93.

RICHARDS, W. H. Back filling. 50, trans 84.

Pipe under Lake Champlain. CRANDALL, F. H. 259, 260, V 12 No 4 June 98.

Pipes.

ALLIS, S. M., and others. Size of main pipes: disc. 18-25, V 5 No 1 Sept 90.

BRACKETT, DEXTER.

Minimum size allowable for mains. 18-20, V 6 No 1 Sept 91.

Raising or lowering of large pipes. 198, 199, V 3 No 4 June 89.

Scrapers for pipe cleaning. 4, V 1 No 3 Mar 87.

Size of Y branches: casting and coating. Diag. Plate VIII. 78, V 8 No 2 Dec 93.

CHACE, G. F. Sixteen-inch direct river pipe and its effect on Taunton water supply. 179-181, V 6 No 4 June 92.

CRAFTS, N. H. Cast-iron pipes: abstract from Watertown Water Works report, with tables. 175-196, V 3 No 4 June 89.

DARLING, EDWIN. Necessity for large size pipes. 180, V 4 No 4 June 90.

FORBES, F. F. Galvanized pipes in driven wells. 143, 144, V 5 No 3 Mar 91.

FREEMAN, J. R. Arrangement and size for fire protection. 49-77, disc 77-81, V 7 No 1 Sept 92; 152-164, V 7 No 3 Mar 93.

HANCOCK, J. C. Sizes and material: disc in relation to Springfield main. 150-153, V 3 No 4 June 89.

HILL, W. R. Fifty-four inch steel submerged in Skaneateles lake, Syracuse, N. Y. Diags. 40-45, V 8 No 1 Sept 93.

JONES, E. R. Protection from frost. 125-127, V 3 No 3 Mar 89.

N E W W A, standard specifications for size and weight. Diags and tables. 335-366, disc 367-383, V 16 No 4 Dec 02 and 84-96, V 17 No 1 Mar 03.

NOYES, A. F. Sizes and weights. Diags. 154-159, disc 28-51, trans 85.

SAVILLE, C. M. Pipes and pipe laying. 203-226, disc 226-230, V 17 No 2 June 03.

STACY, G. A. Experiment and failure: separation from hydrant. 24-26, V 7 No 1 Sept 92.

Water log section from Boston aqueduct, 1836. Ill. 71, V 13 No 1 Sept 98.

WELLS, G. L. Improved Wyckoff water pipe. Ills. 288-303, V 13 No 4 June 99.

Pipes.

Cast iron. *See* Cast-iron pipes.

Castings. *See* Casting and coating of pipes.

Cement lined. *See* Cement-lined pipes.

Coating. *See* Coating of pipes.

Compound. *See* Compound pipes.

Corrosion. *See* Corrosion of pipes.

Electrolysis. *See* Electrolysis of pipes.

Fire protection. *See* Fire protection.

Fish in. *See* Fish in pipes,

Flanges. *See* Flanges for pipes.

Joints. *See* Joints of pipes.

Laying. *See* Laying of pipes.

Leakage from. *See* Leakage from pipes.

Organisms in. *See* Organisms.

Removal of. *See* Removal of pipes.

Service. *See* Service pipes.

Stave. *See* Stave pipes.

Steel. *See* Steel pipes.

Piston meters liable to over-register. HASKELL, J. C. Disc 97-99, V 10 No 2 Dec 95.

Pitcher, F. H. Pumping by electricity. Plans and ills. 349-373, V 17 No. 4 Dec 93.

Pits in block tin service pipes. WHITNEY, J. C. 88, V 6 No 2 Dec 91.

Pits in pipes, Peoria Water Co. KNUDSON, A. A. 250, V 15 No 3 Mar 91.

Pittsburg, Pa. KNOWLES, MORRIS. Experimental filter plant and results. 148-184, disc 185-188, V 15 No 2 Dec 90.

Plankton method for study of micro-organisms. SEDGWICK, Prof W. T. 57-64, V 14 No 1 Sept 99.

Platform (portable) to aid in excavating trenches. COGGESHALL, R. C. P. 125, 126, V 9 No 2 Dec 94.

Platinum standard for determining color of water. 105-111, disc 112, 113, V 13 No 2 Dec 98.

Plugs.

BRACKETT, DEXTER. Diag and dimensions. Plate X. 78, V 8 No 2 Dec 93.

N E W W A. Com. Table. 93, V 7 No 1 Mar 93.

STACY, G. A. Plugs for hydrants. 11, V 4 No 1 Sept 89.

WALKER, C. K. Experience talk. 220, V 7 No 4 June 93.

- Plumbers and licenses.** HOWLAND, A. H., and others. Disc 26-28, V 1 No 1 Sept 86.
- Plunger pump 1675 described.** 37, V 1 No 1 Sept 86.
- Poisoning by water drawn through lead service pipes.** FORBES, F. F. 58-60, disc 60-62, V 15 No 1 Sept 00.
- Pollution of rivers.**
CLARK, H. W. Pollution of streams by manufactural wastes. 500-510, disc 510-513, V 15 No 6 Dec 01.
MIDDLETON, R. E. 119-129, disc 129-137, V 13 No 2 Dec 98.
- Poncelet's and Kutter's formulæ.** TRAUTWINE, J. C., Jr. Letter. 18, 19, V 1 No 2 Dec 86.
- Ponds, Great: relation to water supplies.**
JACKSON, J. F. 203-208, V 4 No 3 June 89.
STETSON, T. M. Mass water laws. 1-18, V 1 No 4 June 87.
- Poppet valves and frozen hydrants.** TIDD, M. M. 14-16, V 1 No 2 Sept 87.
- Porter, Prof Dwight.**
Hydraulic laboratory of Mass Inst of Technology. Ills. 81-84, V 8 No 2 Dec 93.
Velocity curves. Diags. 191-194, V 8 No 4 June 94. See Hastings, L. M.
- Porter, H. F. J.** Steel forgings for pumping engines. Ills and diags. 120-144, V 12 No 2 Dec 97.
- Portland reservoir, Me.** FREEMAN, J. R. Bursting of. Diags. 148-152, disc 152-154, V 8 No 3 Mar 94.
- Portraits of past presidents N E W W A, 1882-1887.** 276-284, V 16 No 4 Dec 02.
See also N E W W A, Portraits.
- Portsmouth Water Works, N H.** AYRES, J. O. 67-69, disc 69, 90, V 13 No 1 Sept 98.
- Poughkeepsie Water Works, N Y.** FOWLER, C. E. Operation of a slow sand filter. Diags and tables. 209-227, disc 227-244, V 12 No 4 June 98.
- Power.**
Dwight Printing Co, Ashland. Development of power before and after diversion of Whitehall pond. 198-200, V 7 No 4 June 93.
HOLLIS, I. N. Economy in the use of coal for the production of power. 32-40, disc 40-43, V 17 No 1 Mar 03.
- Practical management of water works.** DARLING, EDWIN. 7-11, disc 11-18, V 2 No 1 Sept 87.
- Precision in everyday life.** SHERMAN, W. B. 52-56, disc 56, 57, V 17 No 1 Mar 03.
- Present pumping engine practice.** REYNOLDS, I. H. 172-200, disc 200-205, V 13 No 3 Mar 99.
- Presidents of N E W W A.** See N E W W A, Presidents.

Pressure gages.

- PERRY, F. G. Recording. 255-257, disc 257-261, V 10 No 4 June 96.
 WINSLOW, G. E. Air in. 248, V 9 No 4 June 95.

Pressure.

- FRENCH, E. V. Loss caused by meters in factory fire supplies. Tests.
 Diags. 74-94, disc 95-102, V 12 No 2 Dec 97.
 GOWING, E. H. Reduced on a gravity system. 139-142, disc 142-145, V 17 No 2 June 03.

Pressure regulations. E Jersey Water Co, Newark, N J. 27, V 8 No 1 Sept 93.**Prince, Mr.** Iron used in pipe making. 56-62, V 11 No 1 Sept 96.**Private fire protection.**

- N E W W A. Com on apportionment of charges. Report. 290-329, V 16 No 4 Dec 02; 201, 202, V 17 No 2 June 03.
 COGGESHALL, R. C. P. Private fire supplies and insurance requirements: disc. 193-197, V 9 No 4 June 95.
 HAMMOND, J. C., and others. Private fire supply charges. 406-440, V 15 No 5 Sept 01.

Private hydrants, sprinklers, etc. SNELL, G. H. 64, 65, 71, V 17 No 1 Mar 03.**Proper size for hydrants.** WINSLOW, G. E., and others. 94, 95, V 2 No 1 Sept 87.**Protection.**

- JONES, E. R. Of pipes from frost. 125-127, V 3 No 3 Mar 89.
 MILLS, H. F. Of inland waters, Mass. 6-10, V 1 No 3 Mar 87.
 SEDGWICK, Prof W. T. Of surface water from pollution. 245-255, disc 255-265, V 11 No 3 Mar 97.
 STACY, G. A. Of pipes from frost. 201-203, V 12 No 3 Mar 98.

Providence bell: depth of. 94, trans 85. Diags and size. 12, V 3 N 1 Sept 88.**Providence R I.**

- FITZGERALD, DESMOND. Rainfall, 1832-1886. 31, 32, V 2 No 2 Dec 87.
 KNUDSON, A. A. Electrolytic action on pipes. Ill. 248, V 15 No 3 Mar 01.
 Regulations for use of private fire supplies. 436-438, V 15 No 5 Sept 01.
 WESTON, E. B. High pressure fire service system. Diags. 85-90, disc 91-93, V 13 No 2 Dec 98.
 Street main flushing. 87, 88, trans 85.

Provincetown, Mass, water supply. HAWES, L. E. Map. 285-290, disc 291-293, V 11 No 4 June 97.**Public and private water works.** HALL, F. E., and others. Which are best? Disc. 17-24, V 4 No 1 Sept 89**Public use of large streams.** CRANDALL, F. H. 344-347, V 11 No 4 June 97.

- Public water supplies.** GOODNOUGH, X. H. Results of systematic examination. 65-78, disc 78-81, V 14 No 1 Sept 99.
- Pump logs, Portsmouth, N H.** AYRES, J. O. 67-69, disc 70, 71, V 13 No 1 Sept 98.
- Pumping capacity.** SHERMAN, W. B. Safe ratio to maximum consumption. 90-98, V 3 No 2 Dec 88; disc 104-119, V 3 No 3 Mar 89.
- Pumping by direct high pressure for fire protection.** ELLIS, G. A. 27-31, V 7 No 1 Sept 92.
- Pumping by electricity.** PITCHER, F. H. 349-373, V 17 No 4 Dec 03.
- Pumping engines.**
- BARRUS, G. H. Possibilities of economy in, as based on latest accomplishments. 163-170, disc 170, 171, V 13 No 3 Mar 99.
- BETTON, J. M. Comparison of compound and triple expansion for small water works. Diags and ills. 218-228, V 13 No 3 Mar 99.
- CODD, W. F. Nantucket pumping engines. Ills. 174-176, V 16 No 3 Sept 02.
- COFFIN, F. C. Gas, gasoline, and oil engines. Diag. 206-217, V 13 No 3 Mar 99.
- DEAN, F. W. Recent practice in. Ills. 85-104, V 8 No 2 Dec 93.
St. Louis Water Works, Mo, specifications for. 172-194, V 11 No 2 Dec 96.
- DEAN and MAIN. Waltham Water Works, Mass, test of pumping engine. 171-173, V 14 No 2 Dec 99.
- FORBES, F. F. Improvements in. 157-162, V 13 No 3 Mar 99.
- Goss, Prof W. F. M. Snow pumping engine test, Indianapolis Water Works, Ind. 49, 50, V 13 No 1 Sept 98.
- HASKELL, J. C. Pumping engine foundation at Lynn, Mass. 163, 164, V 5 No 4 June 91.
- LEAVITT, E. D. High grade. Diags. 163-183, disc 184-186, V 9 No 3 Mar 95.
- LORETZ, A. J. 226-233, disc 234-244, V 11 No 3 Mar 97.
- PORTER, H. F. J. Steel forgings for pumping engines. Ills and diags. 120-144, V 12 No 2 Dec 97.
- REYNOLDS, I. H. Edward P. Allis Co present practice compared with that of twenty-five years ago. Diags and ills. 172-200, disc 200-205, V 13 No 3 Mar 99.
- SANDO, W. J. Thirty-million gallon engine trial (Chestnut Hill high service station Met Water Works). 232-243, V 15 No 3 Mar 01.
- SHERMAN, W. B. Duties and consumption of fuel. Diags. 23, 24, trans 83.
- SMITH, J. E. High and low duty: comparison (Andover, Mass). 163-166, disc 166-170, V 14 No 2 Dec 99.
- WINSLOW, G. E. Direct acting: experience in reducing water ram (Waltham). 493-498, disc 498, 499, V 15 No 6 Dec 01.

Pumping machinery.

COFFIN, F. C. Application of gas, gasoline, and oil engines. 206-217, V 13 No 3 Mar 99.

FANNING, J. T. Hydraulic types. Ills. 34-41, V 1 No 1 Sept 86.

SANDO, W. J. Met Water Works. Ills and diags. 299-304, V 15 No 4 June 01.

SWAIN, Prof G. F. Methods of comparing cost of structures. 32-34, V 2 No 3 Mar 88.

WORTHINGTON, C. C. Latest designs in Worthington pumping machinery compared with those of twenty years ago. 229-241, V 13 No 3 Mar 99.

Pumping mains, Friction in several. COFFIN, F. C. Diags and tables. 234-243, V 10 No 4 June 96.

Pumping plant, Electrical.

HAGUE, C. A. 184-195, disc 195-202, V 10 No 3 Mar 96.

TOWER, D. N. In a tube well (Cohasset, Mass). 189-193, disc 193, 194, V 12 No 3 Mar 98.

Pumping stations.

Buffalo Water Works, N Y, and engine room. KNAPP, L. H. Ill. 206, V 14 No 3 Mar 00.

Burlington Water Works, Vt. CRANDALL, F. H. Ill. 153, V 10 No 3 Mar 96.

Manchester, N H. WALKER, C. K. Ills. 65, V 10 No 1 Sept 95.

Marlboro Water Works, Mass. STACY, G. A. Ill. 143-146, V 16 No 2 June 02.

Nashua, N H. HOLDEN, H. G. Ill. 250, V 16 No 4 Dec 02.

Pumping stations, Small. How to obtain the best results. Natick, Mass. GIBBS, W. F. Diags. 167-173, V 16 No 3 Sept 02.

Pumping system, Direct, Taunton. CHACE, G. F. 67-75, disc 76-80, V 6 No 2 Dec 91.

Pumps. LOCKE, A. W. Notes in Holland on canals, pumps, dykes, windmills, etc. 44-49, V 5 No 1 Sept 90.

Pump, Chemical. WESTON, E. B. Ills. 341-344, V 14 No 4 June 00.

Purification of sewage by bacterial methods. KINNICUTT, Prof L. P. Diags. 119-141, disc 142-147, V 15 No 2 Dec 00.

Purification of water.

Methods: disc. 30, 31, V 2 No 3 Mar 88.

CLARK, H. W. Removal of color, etc. from water. 1-8, V 17 No 1 Mar 03.

DROWN, Prof T. M. By freezing. 46-52, V 8 No 1 Sept 93.

Electrical. 183-186, disc 186-188, V 8 No 4 June 94.

HASKELL, J. C. Of surface water by natural forces. 137-144, disc 144-155, V 11 No 2 Dec 96.

HILL, W. R. Of Syracuse reservoir, N Y. 213-216, disc 216-229, V 14 No 3 Mar 00.

- HOLLIS, F. S. Removing organisms. 221-223, disc 223-229, V 14 No 3 Mar 00.
- SEDGWICK, Prof W. T. By sand filtration. Diags. 103-130 (9 plates, Berlin-Stralau, Hamburg & Altona Water Works) after 130, V 7 No 2 Dec 92.
- SOPER, Dr G. A. By ozonization. 1-11, disc 11-19, V 15 No 1 Sept 00.
- SWARTS, Dr G. T. Man's imitation of nature in. 1-14, disc 15-19, V 13 No 1 Sept 98.
- Puritan (S S) walking beam.** HAWES, W. M. 163, 164, V 3 No 4 June 89.
- Purity of inland water (Mass act to protect).** MILLS, H. F. 6-10, V 1 No 3 Mar 87.
- Quality of water supply.**
- CHACE, G. F. Care of mains in relation to. 131-134, V 5 No 3 Mar 91.
- STEARNS, F. P. Effect of storage on. 115-125, V 5 No 3 Mar 91.
- Quicksand.** NOYES, A. F. Experience in excavating. 218, 219, disc 219, 220, V 4 No 4 June 90.
- Quincy Water Works, Mass.** TAYLOR, L. A. Dam. Diags. 167-173, disc 173, 174, V 4 No 3 June 89.
- Quinnipiac, New Haven.** BALL, PHINEHAS. Laying pipe across Chicopee and Quinnipiac. 136, V 5 No 3 Mar 91.
- Rainfall.**
- CHACE, G. F. Rainfall of 1890, 1891. 138, V 6 No 3 Mar 92.
- DAVIS, Prof W. M. Causes of. 338-345, disc by Prof W. H. Niles, 345-350, V 15 No 4 June 01.
- FITZGERALD, D. Amount available for water supply. 41-48, disc 48-54, V 1 No 1 Sept 86.
- In Boston. 29, 30. Providence, R. I. 31, 32, V 2 No 2 Dec 87.
- SWAIN, Prof G. F. Influence of forests on rainfall and the flow of streams. 11-26, V 1 No 3 Mar 87.
- Raising or lowering of large water pipes.** BRACKETT, DEXTER. 198, 199, V 3 No 4 June 89.
- Rammers for tamping under large pipes.** GOWING, E. H., and others. Diags. 177, V 12 No 3 Mar 98.
- Ramming of water pipe trenches.** MCCLINTOCK, W. E. 71-77, V 8 No 2 Dec 93.
- Rams.** BABCOCK, S. E. 59-61, V 3 No 1 Sept 88.
- Rankine on cast-iron pipe in "Civil engineering": note.** 158, trans 85.
- Raphidomonas (Infusorian) in Lynn water.** WHIPPLE, G. C. Ills. 348-357, V 11 No 4 June 97.
- Rates.** See Water rates.
- Ratio of pumping capacity to maximum consumption.** SHERMAN, W. B. 90-98, V 3 No 2 Dec 88, disc 104-119, V 3 No 3 Mar 89.

- Raymond, William G.** Damages to mill powers: abstract from Troy, N Y, water commissioner's report. 152-156, V 13 No 2 Dec 98.
- Reading Water Works, Mass.** BANCROFT, L. M. Iron removal plant. 294-300, V 11 No 4 June 97.
- Reading, Pa, railroad crossing.** KNUDSON, A. A. Water mains at railroad crossing, showing electrolytic action on. 246-248, V 15 No 3 Mar 01.
- Recent practice in pumping engines.** DEAN, F. W. 85-104, V 8 No 2 Dec 93.
- Recent specifications for pumping engines.** DEAN, F. W. 172-194, V 11 No 2 Dec 96.
- Recording gages.**
 GOULD, J. A. Diag. 65-69, V 5 No. 1 Sept 90.
 PERRY, F. G. Use and advantage of recording pressure gages. 255-257, disc 257-261, V 10 No 4 June 96.
- Recording location of mains and services: method.**
 BROWN, A. W. F. Card system. 226-228, V 9 No 4 June 95.
 KIMBALL, G. A. Diag. 157-159, V 8 No 3 Mar 94.
- Records of water works.** GLOVER, A. S. 69-79, V 4 No 2 Dec 89.
- Reducers.**
 BRACKETT, D. Diags and dimensions. Plate XIII. 78, V 8 No 2 Dec 93.
 N E W W A. Table. 353-357, V 16 No 4 Dec 02.
- Reed, Wilmer.** Died Nov 96. Obituary 276, V 11 No 3 Mar 97.
- Refusal of application for water.** CATE, E. W., and others. 32, 33, V 1 No 1 Sept 86.
- Relation of great ponds to water supplies.** JACKSON, J. F. 203-208, V 3 No 4 June 89.
- Relation of light to growth of diatoms.** WHIPPLE, G. C. 1-24, disc 25, 26, V 11 No 1 Sept 96.
- Relation of water-works engineers to fire service of factories.** ATKINSON, E. 58-63, disc 63-83, V 17 No 1 Mar 03.
- Relaying street mains, Malden, Mass.** ALLIS, S. M. 79, 80, V 5 No 2 Dec 90.
- Relief or safety valves in water systems.** BABCOCK, S. E. 57-63, V 3 No 1 Sept 88.
- Removal of color, etc. from water.** CLARK, H. W. 1-8, V 17 No 1 Mar 03.
- Removal of conduit pipe in sections (Sherburne, N Y).** DAVIS, W. E. 125-128, V 5 No 3 Mar 91.
- Removal of iron from ground waters.** CLARK, H. W. 277-280, disc 280-284, V 11 No 4 June 97.
- Rennie, George.** Curved pipe experiments: results (Trans Royal Soc, 1831). 113, V 14 No 2 Dec 99.
- Repairs.**
 San Gabriel Power Co. On stave pipe. Ill. 285, V 13 No 4 June 99.
 TILDEN, J. A. On wrought-iron pipe main. 202, V 3 No 4 June 89.

Reservoir embankment construction. TAYLOR, L. A. Diag. 130-133, disc 134-147, V 8 No 3 Mar 94.

Reservoirs.

COGGESHALL, R. C. P. New Bedford Water Works: method of cleaning. 210, 211, disc 211, 212, V 4 No 4 June 90.

COOK, B. I. Woonsocket, R. I. Diag. 20-26, disc 27-35, V 12 No 1 Sept 97.

CRANDALL, F. H. Burlington, Vt. During construction. Ill. 154, V 10 No 3 Mar 96.

FITZGERALD, DESMOND. Covington reservoir water. 77, V 5 No 2 Dec 90.

FORBES, F. F. Algæ in reservoirs and ponds. 196-204, disc 204-210, V 4 No 4 June 90.

Chara fragilis in reservoirs. 252-254, V 10 No 4 June 96.

FREEMAN, J. R. Portland, Me. Bursting of. Diag. 148-152, disc 152-154, V 8 No 3 Mar 94.

FULLER, F. L. Natick, Mass. Covering reservoir. 383-397, disc 398-417, V 17 No 4 Dec 03.

Ware Water Works, Mass. 53-55, V 2 No 1 Sept 87.

HASKELL, J. C., and others. Cleaning methods: disc. 147-155, V 11 No 2 Dec 96.

HASSAM, W. E. Worcester, Mass. Diags. 153-158, disc 158, 159, V 12 No 3 Mar 98.

HASTINGS, L. M. Cambridge, Mass. Payson Park. Ill. 125-128, V 11 No 2 Dec 96.

HERSCHEL, CLEMENS. E Jersey Water Co. Oak ridge, Clinton and Macopin intake. 19-22, V 8 No 1 Sept 93.

HILL, W. R. Syracuse Water Works, N Y. Method of removing organisms from. Ills. 213-229, V 14 No 3 Mar 00.

HOLDEN, H. G. Nashua, N H. Ill. 250, V 16 No 4 Dec 02.

HOWARD, J. L. Middlesex fells (Met Water Works) construction. Ills. 20-32, disc 33, V 15 No 1 Sept 00.

KNAPP, L. H. Buffalo, N Y. Ill. Plate IV. 208, V 14 No 3 Mar 00.

KNIGHT, C. W. Altoona, Pa, floodwater channels. Ills and diags. 151-162, V 14 No 2 Dec 99.

Kittanning point: plan. 97, V 14 No 2 Dec 99.

Met Water Works. Framingham and Sudbury. 47, V 16 No 1 Mar 02.

NOYES, A. F. Met water supply. 121, V 10 No 2 Dec 95.

OLMSTED, F. L. Met W W, Spot pond reservoir. Ills. 272-287, V 15 No 3 Mar 01.

SAVILLE, C. M. Met Water Works. Forbes Hill. Diags. and ill. 177-222, V 16 No 3 Sept 02.

STACY, G. A. Millham, Marlboro Water Works. 141-144, V 16 No 2 June 02.

Sligo and Millham. 140-146, V 16 No 2 June 02.

TAYLOR, L. A. Newport Water Works, N H. 146-149, disc 149-152, V 12 No 3 Mar 98.

WALKER, C. K. Manchester, N H. High service. Ills, diags. 66-75, V 10 No 1 Sept 95.

WESTON, R. S. Henderson, N C. Cristatella in. Map and diag. 20-26, disc 27-29, V 13 No 1 Sept 98.

WHITTEMORE, W. P. High water alarm for reservoirs and tanks. 21-23, disc 23-25, V 3 No 1 Sept 88.

Reservoirs, Covered.

CHASE, J. C. Albany, Ga. Cheap covered reservoir. 155, 156, V 8 No 3 Mar 94.

COFFIN, F. C. Covered, and their design. Diags. 252-285. Diags. 286-288, V 14 No 3 Mar 00.

FORBES, F. F. Brookline, Mass. Diags. 113-117, V 8 No 3 Mar 94.

FULLER, F. L. Franklin, N H. 160, 161, disc 161, 162, V 5 No 4 Dec 91. Diag. 84, 85, V 7 No 1 Sept 92.

HAZEN, ALLEN. Covered filters and reservoirs. 327, 328, V 11 No 4 June 97.

NOYES, A. F. Covered reservoirs. 124, V 8 No 3 Mar 94.

SWAN, C. H. 45-53, disc 53-66, V 3 No 1 Sept 88.

Reservoirs, Storage.

Comparative table of areas, depths and capacities. 121, V 10 No 2 Dec 95.

STEARNS, F. P. Effect on quality of water. 115-125, V 5 No 3 Mar 91.

Revolving pump: description. 38, V 1 No 1 Sept 86.

Reynolds, Irving H. Present pumping engine practice of E. P. Allis Co compared with that of twenty-five years ago. Ills and diags. 172-200, disc 200-205, V 13 No 3 Mar 99.

Rice, George S., and Evans, George E. Report of Manchester, N H, high service. Diags and ill. 68-75, V 10 No 1 Sept 95.

Rice, L. Frederick.

Methods and apparatus used in recent test of water meters at Boston.

Diags. 67-79, disc 80-89, V 3 No 2 Dec 88.

Remarks on meter tests. 120-125, V 3 No 3 Mar 89.

Richards, Walter H.

Accident on tile pipe conduit, New London, Conn. 164, V 3 No 4 June 89.

Anchor ice: experience, New London, Conn. 1275, V 10 No 4 June 96.

Arrangements of hydrants and water pipes for fire protection: disc. 159-161, V 7 No 3 Mar 93.

Charge for hydrant service. 28, V 1 No 1 Sept 86.

Description of 900 feet cypress stave 24-inch pipe, New London, Conn. 287, V 13 No 4 June 99.

Direct pumping system. 79, V 6 No 2 Dec 91.

Engineers and insurance underwriters. 65, 66, V 17 No 1 Mar 03.

- Furnishing motor power from municipal supply: disc. 160, V 6 No 4 June 92.
- Lead service pipes. 22, 23, V 6 No 1 Sept 91.
- Licensing plumbers: disc. 26, 27, V 1 No 1 Sept 86.
- Necessity for tanks for kitchen boilers, etc. 59, 60, trans 85.
- New London, Conn, high service system. 148-151, V 7 No 3 Mar 93.
- New London, Conn, laying 20-inch main. 178, 179, disc 179-181, V 4 No 4 June 90.
- Service pipe, material, size, etc. 40-50, disc 51-53, 65-67, trans 84.
- Water supply quantity. 137, 138, V 6 No 3 Mar 92.
- Richmond Water Works, Va.** BOLLING, C. E. 39-43, disc 43, 44, V 4 No 1 Sept 89.
- Risks in having but one supply main.** HANCOCK, J. C. 59-62, disc 62, 63, V 6 No 1 Sept 91.
- Robbins, Mayor Gilbert A.** Address to N E W W A, 12 June 88. 1, 2, V 3 No 1 Sept 88.
- Robertson, R. A.** The Venturi meter. Diags and ill. 32-42, disc 43-47, V 7 No 1 Sept 92.
- Robinson, Gov George D.** Address at dinner to Amer W W A and N E W W A, 21 Apr 85. 195-199, trans 85.
- Rochester Water Works, N Y.**
- EGLEE, C. H. Setting hydrants. 12, V 4 No 1 Sept 89.
- KUICHLING, EMIL. Abstract from report. 138-143, V 13 No 2 Dec 98.
- TUBBS, J. N. Direct pumping system. 77-79, V 6 No 2 Dec 91.
- Rogers, Henry W., Pres N E W W A.** Portrait. 284, V 16 No 4 Dec 02.
- Cup joints: disc. 72, V 1 No 1 Sept 86.
- Filtration of water. 54-59, disc 59-62, trans 84.
- Lawrence Water Works, Mass. Diags. 6-9, V 1 No 2 Dec 86.
- Water hammer. 78, V 1 No 1 Sept 86.
- Died 15 April 01. Obituary 365, V 15 No 4 June 01.
- Rome, Ga, Filter Plant.** WESTON, E. B. Description. 348, V 14, No 4 June 00.
- Rotch, Morgan, Mayor.**
- Address to N E W W A, 16 June 86, New Bedford. 3, 4, V 1 No 1 Sept 86.
- Waste of water: disc. 61, 62, V 1 No 1 Sept 86.
- Rotterdam.** SEDGWICK, Prof W. T. Sand filters. 116-119, V 7 No 2 Dec 92.
- Roullier, G. A.** Water meters, Flushing Water Works, N Y. Table. 56-58, disc 59-65, V 5 No 1 Sept 90.
- Rumpus in collecting water rates.** CHACE, G. F. 230-237, disc 238, 239, V 14 No 3 Mar 00.
- Russell, Daniel.** Necessity for tanks for kitchen boilers and water closets: disc. 68, trans 85.
- Rusting of pipes.** See Corrosion of pipes.

- Sabin coating for steel pipes.** HASTINGS, L. M. 321, 322, V 13 No 4 June 99.
- Safety valves, use in distribution systems.** BABCOCK, S. E. 57-63, V 3 No 1 Sept 88.
- St Gabriel station, Montreal Water Works.** PITCHER, F. H. Pumping by electricity. 352-373, V 17 No 4 Dec 03.
- St John, N B.**
MURDOCK, WILLIAM. Water mains. 147-151, V 13 No 2 Dec 98.
Water mains. 333-341, disc 341-344, V 13 No 4 June 99.
Water mains. 34-37, V 15 No 1 Sept 00.
- St Louis, Mo, Water Works.** DEAN, F. W. Specifications for pumping engines: disc. 172-194, V 11 No 2 Dec 96.
- Salisbury, Arnold H.** Died 5 July 01. Obituary 456, V 15 No 5 Sept 01.
- Salt water fire system of Boston.** MCINNIS, F. A. Diags. 304-313, V 13 No 4 June 99.
- San Francisco, Cal.** Regulations for use of private fire supplies. 435, 436, V 15 No 5 Sept 01.
- San Gabriel Power Co.**
Forty-eight inch stave pipe line. Ills. 246-249, V 13 No 4 June 99.
ADAMS, A. L. Illustration showing accident to pipe repaired in four hours. 285, V 13 No 4 June 99.
- Sand blast, Experience with.**
BALL, PHINEHAS. 158, V 3 No 4 June 89.
HARRINGTON, J. L. 166, 167, V 3 No 4 June 89.
- Sand filters.** See Filters, Filtration.
- Sand filters in America.** HAZEN, ALLEN. 227-231, 243, 244, V 12 No 4 June 98.
- Sando, Will J.**
Met water works pumping machinery. Diags, ill. 299-304, V 15 No 4 June 01.
Report on trial of 30,000,000 gallon pumping engine, Chestnut hill high service station, 1, 2 May 00. 232-243, V 15 No 3 Mar 01.
- Sands for filter: selection.** HAZEN, ALLEN. 165-168, V 7 No 3 Mar 93.
- Sanitary condition of water supply.**
LOCKE, W. W. Sanitary inspection of Met Water Works. 483-489, disc 489-492, V 15 No 6 Dec 01.
MIDDLETON, R. E. Sanitary districts and watersheds. 119-129, disc 120-137, V 13 No 2 Dec 98.
SEDGWICK, Prof W. T. Burlington, Vt. 167-183, V 10 No 3 Mar 96.
- Sanitation of water supply in nineteenth century: rise and progress.** SEDGWICK, Prof W. T. 315-337, V 15 No 4 June 01.
- Saville, Caleb Mills.**
Construction of a reservoir and standpipe at Forbes hill, Quincy, Mass. Met W W. Diags and ill. 177-222, V 16 No 3 Sept 02.
Pipes and pipe laying for Met Water Works. Plans and ill. 203-226, disc 226-230, V 17 No 2 June 03.

Schleiter, Henry L. Meters: disc. 68, V 1 No 1 Sept 86.

Scoop wheel: hydraulic machine, described. FANNING, J. T. 35, V 1 No 1 Sept 86.

Scrap iron. GARRETT, JESSE, and others. Use in foundries for pipe making. 55-59, V 11 No 1 Sept 96.

Scrapers for pipe cleaning.

BRACKETT, DEXTER. Notes. 4, V 1 No 3 Mar 87.

KEATING, E. H. Halifax, N S. Scraper. 21, 22, V 5 No 1 Sept 90.

MURDOCK, WILLIAM. St John, N B. Ills. 333-344, V 13 No 4 June 99.

Secretary's annual reports. See N E W W A, Secretary's reports.

Sedgwick, Prof William T.

Algae in water. 206, 207, 210, V 4 No 4 June 90.

Asterionella. 23-25, V 14 No 1 Sept 99.

Biological examination of water. 7-14, V 2 No 4 June 88.

Organisms which cause unpleasant tastes and odors in water. 54-64, V 14 No 1 Sept 99.

Protection of surface waters from pollution. 245-255, disc 255-265, V 11 No 3 Mar 97.

Purification of water by sand filtration. With appendix and 9 plates. 103-130, V 7 No 2 Dec 92.

Recent progress in biological water analysis. Diag. 50-55, disc 56-64, V 4 No 1 Sept 89.

Rise and progress of water supply sanitation in nineteenth century. 315-337, V 15 No 4 June 01.

Sand and mechanical filters: disc. 32-43, 52, 53, V 14 No 1 Sept 99.

Sand filtration: disc. 235-240, V 12 No 4 June 98.

Sanitary condition of Burlington, Vt, water supply. 167-183, V 10 No 3 Mar 96.

Systematic examination of public water supplies. 78-80, V 14 No 1 Sept 99.

Utilization of surface water for drinking. 33-39, disc 39-44, V 5 No 1 Sept 90.

Water borne diseases: disc. 215, 216, 218-221, V 10 No 4 June 96.

Sediment in mains: prevention of: disc. 16, 17, V 4 No 1 Sept 89.

Sedimentation by precipitation tank in rivers. SWARTS, Dr G. T. 11-14, disc 15-19, V 13 No 1 Sept 98.

Selection of sands for a filter. HAZEN, ALLEN. 165-168, V 7 No 3 Mar 93.

Separate high pressure fire service system.

McINNES, F. A. Boston, Mass, salt water fire system. 304-313, V 13 No 4 June 99.

WESTON, E. B. Providence, R. I. Diags. 85-91, disc 91-93, V 13 No 2 Dec 98.

Service boxes.

COOK, B. I., and others. Disc and diags. 305-314, V 15 No 4 June 01.

- HOLDEN, H. G. At street curbing: best form, 41, V 1 No 1 Sept 86.
- LESAGE, T. W. Service boxes of Montreal Water Works. 284-287, V 17 No 3 Sept 03.
- STACY, G. A. Service boxes. 36-38, disc 38-40, V 12 No 1 Sept 97.
Service gate boxes. 339, 340, V 11 No 4 June 97.
- WALKER, C. K. Manchester, N. H. Service gate boxes. 341, 342, disc 343, V 11 No 4 June 97.
- Service and water main location records.** KIMBALL, G. A. 157-159, V 8 No 3 Mar 94.
- Service locations.** Card system. BROWN, A. W. F. 226-228, V 9 No 4 June 95.
- Service pipes.**
- CHACE, G. F. Defects and remedy. 41-45, disc 45-55, V 12 No 1 Sept 97.
- COGGESHALL, R. C. P., and others. New Bedford, Mass.: disc. 22-27, V 6 No 1 Sept 91.
- FORBES, F. F. Brookline, Mass. Cement-lined. 44-48, disc 48-57, V 15 No 1 Sept 00.
Lead poisoning by. 58-60, disc 60-62, V 15 No 1 Sept 00.
- FULLER, F. L. Life of. 221, V 7 No 4 June 93.
- HILL, W. R. Directions for laying. 38, 39, V 13 No 1 Sept 98.
- HOLDEN, H. G. Lead connections for iron pipes? 81, 82, disc 82-89, V 6 No 2 Dec 91.
- JONES, E. R. Protection from frost. 125-127, V 3 No 3 Mar 89.
- N E W W A. Reports of members. 4 tables. Trans 84.
- RICHARDS, W. H. Lead service pipe. 22-27, V 6 No 1 Sept 91.
Material, size, etc. 40-50, disc 51-53, 65-67, trans 84.
- WALKER, C. K. Control and management: disc. 19-22, V 2 No 1 Sept 87.
Thawing frozen pipes: experience. 220, V 7 No 4 June 93.
- Setting of St Paul hydrants.** PARKER, F. H. 11, 12, V 4 No 1 Sept 89.
- Sewage.** HAZEN, ALLEN. Lakes as sources of water supply and receptacles for sewage. 163-166, V 10 No 3 Mar 96.
- Sewage purification by bacterial methods.** KINNICUTT, L. P. 119-141, disc 142-147, V 15 No 2 Dec 00.
- Seymour, Charles W. S.**
Experience with anchor ice and a recording pressure gage, Hingham, Mass. 223-225, V 9 No 4 June 95.
Died 16 Oct 93. Obituary 108, V 8 No 2 Dec 93.
- Shedd, J. Herbert.** Ratio of pumping capacity to maximum consumption. 113-116, V 3 No 3 Mar 89.
- Sherman, Charles W.**
Advertising in the N E W W A JOURNAL. 362, 363, V 15 No 3 Mar 01.
JOURNAL report 1900-01. 74-77, V 16 No 1 Mar 02.

Water-works statistics in JOURNAL. 192, 193, V 15 No 2 Dec 00; Portland, Me, remarks 450-452, V 15 No 5 Sept 01; statistics for 1900, 367-389, V 15 No 5 Sept 01; for 1901, 223-243, V 16 No 3 Sept 02; for 1902, 235-257, V 17 No 3 Sept 03.

Sherman, William B.

Calipering pipe. 35-37, trans 85.

Cast-iron pipe, information wanted. 12-15, V 1 No 1 Sept 86; 91, 92, disc 92, 93, V 2 No 1 Sept 87.

Practical and theoretical precision in everyday life. 52-57, V 17 No 1 Mar 03.

Pumping engine duties, etc. 23, 24, trans 83.

Remarks at dinner of Amer W W A and N E W W A, 21 April 85. 209-211, trans 85.

Report of N E W W A committee on exchange of sketches. 16-18, V 1 No 1 Sept 86.

Suppression policy of Amer Engineers: editorial from "Engineering News," 17 May 84. 28-30, disc 31-38, trans 84.

Table showing water consumption and pumping capacity in various cities for 1886. 35, V 2 No 3 Mar 88.

Uniformity wanted in water-works reports. 143, 144, 149, trans 85.

Water hammer. 75-77, V 1 No 1 Sept 86.

What is safe ratio of pumping capacity to maximum consumption. 90-98, V 3 No 2 Dec 88; disc 104-110, V 3 No 3 Mar 89.

Should plumbers be licensed? HOWLAND, A. H., and others. 26-28, V 1 No 1 Sept 86.

Silk mill wastes polluting streams. CLARK, H. W. 500-510, V 15 No 6 Dec 01.

Simin, Nicholas, Chief Engr Moscow Water Works, Russia. Address to N E W W A. 65, V 12 No 1 Sept 97.

Simmons, Hon William A. Remarks at dinner of Amer W W A and N E W W A, 21 Apr 85. 202-205, trans 85.

Sinking funds.

COFFIN, F. C. 63-86, disc 87-98, V 11 No 1 Sept 96.

FITZGERALD, D. 185, 186, V 6 No 4 June 92.

FULLER, F. L. 103-105, disc 105-110, V 12 No 2 Dec 97.

Tables. 30, 31, V 1 No 3 Mar 87.

Siphon laying under Broad canal, Cambridge. HARRINGTON, J. L. Diags. 90-95, V 7 No 2 Dec 92.

Siphon pipes and plugs. Diag and dimensions. BRACKETT, DEXTER. Plate X. 78, V 8 No 2 Dec 93.

Sizes of pipes. See Pipes, sizes.

Skaneateles lake, Syracuse Water Works. HILL, W. R. 40-45, V 8 No 1 Sept 93.

Skating rinks, Use of hydrant water for. WALKER, C. K., and others: disc. 143-146, V 10 No 3 Mar 96.

Sketches and blue prints. See N E W W A committees.

Sleeves. Diags and dimensions.

BRACKETT, DEXTER. Plate XI. 78, V 8 No 2 Dec 93.

Of cast-iron pipes. N E W W A, pipes. 358, V 16 No 4 Dec 02.

Slow sand filters, Poughkeepsie, N Y. FOWLER, C. E. 209-227, disc 227-244, V 12 No 4 June 98.**Smith, Prof H. E.**

Electrical purification of water. 186, V 8 No 4 June 94.

Experience in sinking funds. 106, 107, V 12 No 2 Dec 97.

Smith, J. Waldo. Pressure reducing valves. 143, V 17 No 2 June 03.**Smith, John E.** Comparison between high and low duty pumping engines in a small water-works plant. 163-166, disc 166-170, V 14 No 2 Dec 99.**Smith, Dr Theobald.** Water-borne diseases, cholera, typhoid, malaria, etc. 203-214, disc 214-225, V 10 No 4 June 96.**Snell, George H.** Private hydrants, sprinkler systems, and insurance. 64, 65, 71, V 17 No 1 Mar 03.**Snow pumping engine test at Indianapolis, Ind, Water Works.** GOSS, Prof W. F. M. 49-54, V 13 No 1 Sept 98.**Soft answer: advice to superintendents.** GARDNER, L. H. 129-131, V 5 No 3 Mar 91.**Soils from which water supplies may be drawn by filter galleries or driven wells.** BALL, P. 29-32, disc 33, 34, V 3 No 1 Sept 88.**Somerville Water Works, Mass.** Service box. Diag. 307, V 15 No 4 June 01.**Soper, Dr George A.** Ozonization of water. 1-11, disc 11-19, V 15 No 1 Sept 00.**Sources of water supply.**

HAWES, L. E. Springs. Diags. 156-171, V 11 No 2 Dec 96.

STEARNS, F. P. Selection of. 102-127, disc 128-138, V 6 No 3 Mar 92.

Southwest (Arid) Arizona. Experiences. ALLIS, S. M. Map. 261-269, V 12 No 4 June 98.**Sparks, H. T.**

Electrolysis, Brewer, Me. 42, 43, V 9 No 1 Sept 94.

Experience with anchor ice. 276, V 10 No 4 June 96.

Specifications.For cast-iron pipe. *See* Cast-iron pipe.For water works. *See* Water works.**Spellman, John D., Mayor of Rutland, Vt.** Address to N E W W A, nineteenth annual meeting. 196, V 15 No 2 Dec 00.**Spigot and bell of cast-iron pipe, Yarmouth, N S.** COFFIN, F. C. Diag. 38, V 15 No 1 Sept 00.**Spot pond reservoir, Middlesex Fells (Met Water Works).**

HOLLIS, F. S., and PARKER, H. N. Chlamydomonas. Diags. 26-29, disc 30, 31, V 14 No 1 Sept 99.

OLMSTED, F. L. Landscape problems in the improvement of. Ills. 272-287, V 15 No 3 Mar 01.

- Sprague, Phineas.** Died 14 Sept 87. Obituary 35, V 2 No 2 Dec 87.
- Springfield, Mass.** HANCOCK, J. C. Flushing street mains. 71, 73, trans 85.
- Springfield fire department.** Hose discharge experiments. 152, trans 85.
- Springs utilized as town water supply source.** HAWES, L. E. Diags. 156-171, V 11 No 2 Dec 96.
- Sprinklers.**
- CROSBY, E. U. Regulations of Nat Fire Protection Assn. 103-109, V 15 No 2 Dec 00.
- FRENCH, E. V., and others. (Automatic) and loss of water. 97-101, V 12 No 2 Dec 97.
- GERHARD, W. P. For fire protection in theaters, etc. 85-89, V 9 No 2 Dec 94.
- SNELL, G. H. Private hydrants, sprinklers, etc. 64, 65, 71, V 17 No 1 Mar 03.
- Stacy, George A., Pres N E W W A.**
- Address to N E W W A on election to presidency. 17, 18, V 9 No 1 Sept 94.
- Address to N E W W A, 11 Sept 95, Burlington, Vt. 5-8, V 10 No 1 Sept 95.
- Control of hydrants. 145, 146, V 10 No 3 Mar 96.
- Fire protection for manufactories. 177, V 7 No 3 Mar 93.
- Hydrants. 32-37, disc 37, 38, V 4 No 1 Sept 89.
- Lead connections in service pipes. 83, 84, V 6 No 2 Dec 91.
- Lead joints. 99, trans 85.
- Location of broken mains and examination of hydrants in cold weather. 222-224, V 7 No 4 June 93.
- Marlborough Water Works, Mass. Ills. 139-150, V 16 No 2 June 02.
- Meters; disc. 64, V 1 No 1 Sept 86.
- Over-registration of meters. 99-108, V 10 No 2 Dec 95.
- Plugs for hydrants. 11, V 4 No 1 Sept 89.
- Protection of water pipes from freezing. 201-203, V 12 No 3 Mar 98.
- Reservoir cleaning. 28, 29, V 12 No 1 Sept 97.
- Separation of pipe from hydrant: experiment and failure. 24-26, V 7 No 1 Sept 92.
- Service boxes. 36-38, disc 38-40, V 12 No 1 Sept 97.
- Service gate boxes. 339, 340, V 11 No 4 June 97.
- Testing water pipe distributing systems. 337, V 11 No 4 June 97.
- Stacy service box.** CONNET, F. N. Plate I. 308, 309, V 15 No 4 June 01.
- Stagnation of water increases color.** HOLLIS, F. S. 97-99, V 13 No 2 Dec 98.
- Standard flanges for pipes.** See Flanges.
- Standard hydrants.** See Hydrants.
- Standard special castings.** See Castings.
- Standard specifications for cast-iron pipe.** See Cast-iron pipe.
- Standard specifications for water works.** See Water works.

Standard required for testing meters: disc. 113-116, V 10 No 2 Dec 95.
Standpipe system for fire protection. ELLIS, G. A. 27-31, V 7 No 1 Sept 92.
Standpipes.

BASSETT, C. P. Atlantic Highlands, N J. High and low service.
 Diags. 215-219, V 7 No 4 June 93.

BEALS, J. E. Middleboro, Mass. Painting of standpipe. 157, 158,
 V 3 No 4 June 89.

CHASE, J. C. Experience with wooden bottom. 68-70, V 8 No 2 Dec 93.

COFFIN, F. C. And their design. Diags. 202-214, V 7 No 4 June 93.

COGGESHALL, R. C. P. Fall of Fairhaven water tower. Ills. 522-
 524, V 15 No 6 Dec 01.

COOK, B. I. Woonsocket, R I. 124-127, disc 127-132, V 14 No 2
 Dec 99.

KIERAN, PATRICK. Fall River, Mass. Diag. 25-27, disc 27-32, V 2
 No 1 Sept 87.

NYE, J. K. Fairhaven, Mass. Diags. 175-180, disc 180-182, V 8
 No 4 June 94.

SAVILLE, C. M. Quincy, Mass (Forbes Mill). 177-222, V 16 No 3
 Sept 02.

STACY, G. A. Marlborough, Mass. Ill. 146-148, V 16 No 2 June 02.

WHITTEMORE, W. P. High water alarm for. 21-23, disc 23-25, V 3
 No 1 Sept 88.

Stanwood, James Hugh. Died 25 May 96. Obituary 275, V 11 No 3
 Mar 97.

Statistics of water works. Statistics, tables, reports, etc.

1886. 28-31, V 1 No 4 June 87.

1887. 5 tables after 27, V 2 No 4 June 88.

1888-92. After 225, V 7 No 4 June 93.

1893. 5 tables 127-134, V 9 No 2 Dec 94.

1894. 131-138, V 10 No 2 Dec 95.

1895-6. 273-288, V 12 No 4 June 98.

1897-9. 65-95, V 15 No 1 Sept 00.

1900. 367-389, V 15 No 5 Sept 01.

1901. 223-243, V 16 No 3 Sept 02.

1902. 235-257, V 17 No 3 Sept 03.

Stave pipe: its economic design and use. ADAMS, A. L. Ills and diags.
 247-287, disc 287, V 13 No 4 June 99.

Stealing water.

ATKINSON, EDWARD, and others. 58-63, disc 63-83, V 17 No 1 Mar 03.

KIMBALL, G. A. 187-190, V 4 No 4 June 90.

Steam and water power. Dwight Printing Co, Ashland. 198-200, V 7
 No 4 June 93.

Steam fire engines, hydrants, and hose. Capacity tests. BRACKETT, D.
 With tables. 154-162, V 9 No 3 Mar 95.

Steam pressure. E. P. Ellis Co pumping engines. REYNOLDS, I. H.
 194, V 13 No 3 Mar 99.

S S "Puritan" walking beam. HAWES, W. M. 163, 164, V 4 No 3 June 89.
Stearns, Frederic P.

Aëration of natural waters. 102, V 7 No 2 Dec 92.

Alge and infusoria in water. 96, 97, V 6 No 2 Dec 91.

Bacteria, Typhoid. 22-25, V 2 No 4 June 88.

Biological water analysis: disc. 58-60, V 4 No 1 Sept 89.

Chemical analysis of water. 16, 17, 26, V 3 No 2 Mar 88.

Effect of storage on quality of water. 115-123, disc 123-125, V 5
 No 3 Mar 91.

Selection of sources for water supply, with tables. 102-127, disc
 128-138, V 6 No 3 Mar 92.

Steben, B. F. Iron *v* cement pipes. 55, 56, V 5 No 1 Sept 90.

Steel for water mains. HASTINGS, L. M. Ills. 314-324, V 13 No 4
 June 99.

Steel forgings for pumping engines. PORTER, H. F. J. Ills and diags.
 120-144, V 12 No 2 Dec 97.

Steel pipes.

BRACKETT, DEXTER. Protection against corrosion. 325-331, V 13
 No 4 June 99.

EVANS, G. E., and others. *v* cast-iron pipes (New Bedford Water
 Works): disc. 219-223, V 11 No 3 Mar 97.

HASTINGS, L. M. Curved 40-inch steel riveted pipe, Payson Park
 reservoir, Cambridge, Mass. Ill. 128-132, V 11 No 2 Dec 96; 316,
 V 13 No 4 June 99.

Over railroad. Ill. 218, V 13 No 4 June 99.

HILL, W. R. Fifty-four inch submerged in Skaneateles lake, Syracuse,
 N Y. Diag. 40-45, V 8 No 1 Sept 93.

WOOD, EDMUND. Forty-eight inch force main, New Bedford Water
 Works, Mass. Ill. 210, 211.

Reasons for use. 212, 213, V 11 No 3 Mar 97.

Stetson, Thomas M. A resource for cheap water for the people. Mass
 great pond water laws. 1-18, V 1 No 4 June 87.

Stoddard, Samuel G. Died 21 Aug 01. Obituary 451, V 15 No 5 Sept 01.

Stone, Charles A., and Forbes, Howard C. Electrolysis of water pipes.
 Diag. 25-36, disc 36-43, V 9 No 1 Sept 94.

Stone pipes: history. GARRETT, JESSE. 36, 37, V 11 No 1 Sept 96.

Storage basins. HASKELL, J. C., and others. Method of cleaning: disc.
 147-155, V 11 No 2 Dec 96.

Storage, effect on quality of water. STEARNS, F. P. Table. 115-125,
 V 5 No 3 Mar 91.

Storage reservoirs. Comparative table of areas, depths, and capacities.
 121, V 10 No 2 Dec 95.

Storrs, Prof H. A. Electrolysis of pipes. Diags. 33-42, disc 42-47,
 V 10 No 1 Sept 95.

Straight pipes. Standard weights. N E W W A Com table. 344, V 16
 No 4 Dec 02.

Streams, Large.

Inexpensive method of determining public use of. CRANDALL, F. H.
344-347, V 11 No 4 June 97.

Pollution of, by manufactural wastes, and prevention. CLARK, H. W.
500-510, disc 510-513, V 15 No 6 Dec 01.

Street mains. *See* Mains.

Street railway electric systems and electrolysis of pipes. *See* Electrolysis.

Structures or machines of different classes, Economy of. SWAIN,
Prof G. F. 32-34, V 2 No 3 Mar 88.

Submerged steel pipe. *See* Steel pipes, and Syracuse Water Works, N Y.

Sudbury and Cochituate watersheds: capacity in drought. FITZGERALD, D.
12-21, tables and diags 22-32, V 2 No 2 Dec 87.

Sudbury River: monthly yield. FITZGERALD, D. 1875-1886. Diag.
14, V 2 No 2 Dec 87.

Sullivan, Jeremiah F., Mayor of Holyoke, Mass. Address to N E W W A,
8 June 92. 1, 2, V 7 No 1 Sept 92.

Sulphate of alumina: purification of water supplies. WESTON, E. B.
333-362, V 14 No 4 June 00.

Superintendents of water works, Advice to. GARDNER, L. H. The soft
answer. 120-131, V 5 No 3 Mar 91.

Supply mains. *See* Mains.

Suppression policy of Amer Engrs. Editorial from "Eng News," 17 May 84.
SHERMAN, W. B. 28-30, disc 31-38, trans 84.

Surface water.

DROWN, Prof T. M. Odor and color, chemical aspect. 3-15, disc
15-29, V 2 No 3 Mar 88.

HASKELL, J. C. How to secure pure water from. 137-144, disc
144-155, V 11 No 2 Dec 96.

Water supplies of Mass. 79-84, V 13 No 2 Dec 98.

HOLLIS, F. S. Determination of color and relation to character of
water. Diags. 94-111, disc 112-118, V 13 No 2 Dec 98.

SEDGWICK, Prof W. T. For drinking. 33-39, disc 39-44, V 5 No 1
Sept 90.

Purification by sand filtration. Ill. 103-130, V 7 No 2 Dec 93.

Protection from pollution. 245-255, disc 255-265, V 11 No 3 Mar 97.

STEARNS, F. P. Quantity and quality. 102-128, disc 128-138, V 6
No 3 Mar 92.

WHIPPLE, G. C. Temperature and its effects on growth of micro-
organisms. Diags. 202-216, disc 216-222, V 9 No 4 June 95.

WHIPPLE, G. C., and JACKSON, D. D. Seasonal distribution of asterionella. Diag. 8, V 14 No 1 Sept 99.

WINSLOW, C.-E. A. Bacteria per cubic centimeter. Boston tap,
Merrimac and Thames rivers. 465, 466, V 15 No 6 Dec 01.

Swain, Prof George F.

Economy of structures of different classes: methods of comparison.
32-34, V 2 No 3 Mar 88.

- Influence of forests on rainfall and the flow of streams. 11-26, V 1 No 3 Mar 87.
- Swamp drainage for watershed improvement.** LARNED, E. S. 36-44, disc 44-50, V 16 No 1 Mar 02.
- Swan, Charles H.** Covered reservoirs. 45-53, disc 53-56, V 3 No 1 Sept 88.
- Swarts, Dr Gardner T.**
 Man's imitation of nature in purification of water. 1-14, disc 15-19, V 13 No 1 Sept 98.
 Mechanical filtration. 354-357, V 14 No 4 June 00.
- Sweeney scraper for cleaning water pipes.** 21, 22, V 5 No 1 Sept 90.
- Symons, G. J.** Watershed areas and sanitary districts: disc. 133, 134, V 13 No 2 Dec 98.
- Syracuse Water Works, N Y.**
 HILL, W. R. Fifty-four inch submerged steel pipe in Skaneateles lake. Diag. 40-45, V 8 No 1 Sept 93.
 Method of removing organisms from water in distributing reservoir. Ills. 213-216, disc 216-220, V 14 No 3 Mar 00.
 VENNER, JOHN. Municipal use and waste of water. 268-271, V 17 No 3 Sept 03.
- Tamping and ramming in back filling trenches.** GOWING, E. H., and others. 175-188, V 12 No 3 Mar 98.
- Tanks for supply of water closets and kitchen boilers, a necessity.** BILLINGS, W. R. 51-56, disc 56-68, trans 85.
- Tanks, Elevated.** See Standpipes.
- Tannery wastes polluting streams.** CLARK, H. W. 500-510, disc 510-513, V 15 No 6 Dec 01.
- Tapping band on cast-iron pipe for large connections.** TAYLOR, L. A. 220, 230, V 9 No 4 June 95.
- Tar, a preventative of tubercles in iron and steel.** HALE, R. A. 244-251, V 10 No 4 June 96.
- Tarrytown Water Works, N Y.** LEACH, S. B. 136, V 6 No 3 Mar 92.
- Taste and odor imparted to water by algæ and infusoria.** FORBES, F. F. 90-96, disc 96, 97, V 6 No 2 Dec 91.
- Tastes and odors, Unpleasant, caused by organisms.** SEDGWICK, Prof W. T. 54-64, V 14 No 1 Sept 99.
- Taunton, Mass.**
 BILLINGS, W. R. Direct pumping system. 77, V 6 No 2 Dec 91.
 Street main flushing. 85-87, trans 85.
 CHACE, G. F. Artesian well experiment. 221-223, disc 223, 224, V 4 No 4 June 90.
 Cement-lined service pipes. 24, V 6 No 1 Sept 91.
 Direct pumping system, three years' experience. 67-75, disc 76-80, V 6 No 2 Dec 91.

- Effect of 16-inch direct river pipe on supply. 179-181, V 6 No 4 June 92.
- Handling fires while changing mains upon important streets. 230-233, V 10 No 4 June 96.
- Laying a 16-inch main across a rocky stream and over dam. 103-105, V 9 No 2 Dec 94.
- Rumpus in collecting meter rates. 230-237, disc 238, 239, V 14 No 3 Mar 00.
- Taylor, Charles N.** Depth of driven wells. 134-136, V 17 No 2 June 03
- Taylor, Lucian A.**
- Construction of reservoir embankments. Diags. 130-133, disc 134-147, V 8 No 3 Mar 94.
- Construction of the Newport, N H, Water Works. 145-149, disc 149-152, V 12 No 3 Mar 98.
- Experience with a water meter. 182, V 6 No 4 June 92.
- Necessity for more than one supply main: disc. 63, V 6 No 1 Sept 91.
- Quincy dam. Diags. 167-173, disc 173, 174, V 3 No 4 June 89.
- Use of tapping band on cast-iron pipe for large connections. 229, 230, V 9 No 4 June 95.
- Water meters. 57-60, disc 60-68, V 1 No 1 Sept 86.
- Weight of cast-iron pipe. 40, 41, trans 85.
- Woodbridge dam, Conn. 51-55, disc 55, 56, V 6 No 1 Sept 91.
- Taylor, William D.** Died 2 Jan 94. Obituary 195, V 8 No 4 June 94.
- Telemeter in standpipes.** COOK, B. I., and others. Disc. 130-132, V 14 No 2 Dec 99.
- Temperature of surface waters and effect on growth of micro-organisms.**
- WHIPPLE, G. C. Diags. 202-216, disc 216-222, V 9 No 4 June 95.
- Temporary dam, New Bedford, Mass.** COGGESHALL, R. C. P. 200, 201, V 3 No 4 June 89.
- Tenement-house water consumption, N Y.** WASHINGTON, W. d'H. 236-238, V 9 No 4 June 95.
- Terre Haute, Ind, flushing laterals.** HOWLAND, A. H. 91, 92, trans 85
- Test of lifting water from wells with air.** DAVIS, F. A. W. 51-54, V 13 No 1 Sept 98.
- Test of new pumping engine, Waltham, Mass.** DEAN AND MAIN. 171-173, V 14 No 2 Dec 99.
- Test of Snow pumping engine, Indianapolis, Ind.** GOSS, Prof W. F. M. 49-54, V 13 No 1 Sept 98.
- Testing Newton mains.** HYDE, H. N. 336, 337, V 11 No 4 June 97.
- Testing of joints and pipes.** HILL, W. R., and others. Disc. 41-44, V 13 No 1 Sept 98.
- Testing of pipes by manufacturers.** DARLING, EDWIN. 37, 38, trans 85.
- Testing, uniformity of method.** THOMSON, J. Diags. 77-96, disc 96-108, V 10 No 2 Dec 95.
- Testing water pipe distribution systems.** FULLER, F. L. Ills. 330-335, disc 335-338, V 11 No 4 June 97.

Testing water meters.

BILLINGS, W. R., and others. Best method. Disc. 93, 94, V 2 No 1 Sept 87.

KIMBALL, F. C. Some 6-inch meter tests and how made. 305-331, disc 331-337, V 17 No 4 Dec 03.

Testing: remarks. RICE, L. F. 120-125, V 3 No 3 Mar 89.

Tests by tubular wells for amount of water supply (Kingston, Mass).

BOYCE, W. C. 26-28, V 3 No 1 Sept 88.

Tests of articles of commerce to be conducted by N E W W A. HERSCHEL,

CLEMENS. 109-111, disc 111-116, V 10 No 2 Dec 95.

Tests of rotary and disc meter systems. HAWLEY, W. C. 111-119, V 12

No 2 Dec 97.

Tests of water meters. RICE, L. F. 67-79, disc 80-89, V 3 No 2 Dec 88.

Thawing hydrants. BAILEY, G. I. Apparatus. 121, V 14 No 2 Dec 99.

Thawing macadam surfacing by steam, for trench making. WESTON,

E. B., and others. Providence, R I. 90, 91, V 13 No 2 Dec 98.

Thawing service pipes: experience. WALKER, C. K. 220, V 7 No 4 June 93.

Theatres, fire protection and water service. GERHARD, W. P. 77-92,

V 9 No 2 Dec 94.

Thermophone: described. WHIPPLE, G. C. Diag. 203, 204, 218-222,

V 9 No 4 June 95.

Thickness and weight of standard cast-iron pipe. N E W W A table.

343, V 16 No 4 Dec 02.

Thomas, R. J.

Frozen hydrants. 145, V 10 No 3 Mar 96.

Report of advertising in N E W W A JOURNAL 77-79, V 16 No 1 Mar 02.

Thomson, John.

Is the game worth the candle? (Meters.) 58-67, V 8 No 2 Dec 93.

Meters. 45-47, V 7 No 1 Sept 92.

Uniformity of methods in testing meters. Diags. 77-96, disc 96-

108, V 10 No 2 Dec 95.

Three-crank compound engine. See Pumping engines.

Tidd, Marshall M.

Driven wells: disc. 79-81, V 1 No 1 Sept 86.

Filter galleries on borders of rocky ponds. 106-108, V 5 No 3 Mar 91.

Poppet valves and frozen hydrants. 14-16, V 1 No 2 Sept 87.

Reservoir embankment construction. 135-138, 140, V 8 No 3 Mar 94.

Service pipes. 21, V 2 No 1 Sept 87.

Specifications for water works. 176-178, V 6 No 4 June 92.

Use and weight of special castings: disc. 9-12, V 3 No 1 Sept 88.

Water hammer. 75, 76, V 1 No 1 Sept 86.

Water tanks: disc. 27-32, V 2 No 1 Sept 87.

Died 20 Aug 95. Obituary 76, V 10 No 1 Sept 95.

Tilden, J. A.

Repairs on wrought-iron pipe main. 202, V 3 No 4 June 89.

Testing of water meters: disc. 88, 89, V 3 No 2 Dec 88.

Testing of water meters. 332-334, V 17 No 4 Dec 03.

Water supply sources. 133-135, V 6 No 3 Mar 92.

Tile pipe conduit, accident, New London, Conn. RICHARDS, W. H. 164, V 3 No 4 June 89.

Tin-lined iron service pipe. CHACE, G. F. 45, V 12 No 1 Sept 97; 56, 57, V 15 No 1 Sept 00.

Tintometer (Lovibond). HOLLIS, F. S. 104, V 13 No 2 Dec 98.

Tonawanda Water Works, N Y. FALES, F. L. 23, V 4 No 1 Sept 89.

Tower, D. N. Handling air in a tube-well pumping plant, Cohasset, Mass. 189-193, disc 193, 194, V 12 No 3 Mar 98.

Trautwine, John C., Jr.

Appeal for aid for Kutter family. 7, V 3 No 1 Sept 88.

Letter in regard to Poncelet's and Kutter's formulæ. 18, 19, V 1 No 2 Dec 86.

Letter soliciting co-operation of N E W W A with Assn of Eng Soc's. 137-139, V 9 No 3 Mar 95.

Trenches. See Pipe trenches.

Trolley system affecting pipes. See also Electrolvsis.

WILLIAMS, G. S. 44, 45, V 10 No 1 Sept 95.

WINSLOW, G. E. 42-45, V 10 No 1 Sept 95.

Troy Water Works, N Y. Abstract of report: damage to mill powers. RAYMOND, W. G. 152-156, V 13 No 2 Dec 98.

Tryon, James. What a water supply engineer can do for the fire department. 93-102, V 9 No 2 Dec 94.

Tubbs, J. Nelson.

Direct pumping system, Rochester Water Works, N Y. 77-79, V 6 No 2 Dec 91.

Some reasons why a municipal water supply should not furnish motor power. 152-155, disc 155-160, V 6 No 4 June 92.

Tube wells.

BOWERS, GEORGE. Experience, Lowell, Mass. 67-76, V 9 No 2 Dec 94. Experiments and result. 30-33, disc 33-35, V 13 No 1 Sept 98.

Second plant at Lowell. 226-228, disc 229, V 10 No 4 June 96.

BOYCE, W. C. Tests for amount of water supply. 26-28, V 3 No 1 Sept 88.

Tubercles in iron and steel penstocks. HALE, R. A. Ills. 244-251, V 10 No 4 June 96.

Tuberculation and sediment in service pipes: disc. 105-107, V 8 No 2 Dec 93.

Turbidimeter. ANTHONY, C., Jr. Diag. 256-262, V 16 No 4 Dec 02.

Turbines and pumps, Willimantic Water Works, Conn. Ills. 40, V 1 No 1 Sept 86.

Twenty years after. COWGESHALL, R. C. P. Retrospect of N E W W A. 271-289, V 16 No 4 Dec 02.

Typhoid.

CLARK, H. W. In Lawrence, 1892-1898. 83-86, V 14 No 1 Sept 99.

MASON, W. P. Traced to water, Cohoes, N Y. 143, 144, V 6 No 3 Mar 92.

MILLS, H. F. In Lawrence. Diags. 44-55, disc 55-57, V 9 No 1 Sept 94.

In its relation to water supplies. Tables. 149-156, disc 156-160, V 5 No 4 June 91.

SEDGWICK, Prof W. T. Epidemics caused by pollution of surface water. 245-255, disc 255-266, V 11 No 3 Mar 97.

Epidemic in Lausen, Switzerland. 327-331, V 15 No 4 June 01.

WINSLOW, C.-E. A. Bacillus: isolation. 469-471, V 15 No 6 Dec 01.

Epidemic in Ithaca, N Y. and Lawrence, Mass, etc. 171-173, V 17 No 2 June 03.

Typhoid bacteria. See Bacteria, Typhoid.

Underground piping systems, Electrolysis of. KNUDSON, A. A. 244-255, disc 255-271, V 15 No 3 Mar 01.

Underground water. BOWERS, GEORGE. 127-132, disc 132-137, V 17 No 2 June 03.

Uniform classification of water rates. HOWLAND, A. H. 15, 16, V 1 No 1 Sept 86; 32-42, disc 42-44, V 2 No 1 Sept 87.

Uniformity in design for special pipe castings. BRACKETT, DEXTER. Tables. 78-80, V 8 No 2 Dec 93.

Uniformity in municipal reports. BAKER, M. N. 189-192, V 15 No 2 Dec 00.

Uniformity of methods in testing water meters. THOMSON, JOHN. Diags. 77-96, disc 96-108, V 10 No 2 Dec 95.

Upton, Albert F. Died 8 June 88. Obituary 99, V 3 No 2 Dec 88.

Uroglena. GOODNOUGH, X. H. Examination of public water supplies. 70-78, disc 78-81, V 14 No 1 Sept 99.

Use and weight of special castings. TIDD, M. M., and others. 9-12, V 3 No 1 Sept 88.

Use of meters and city ownership. CHACE, G. F. 21, 22, V 6 No 1 Sept 91.

Use of water from hydrants. WALKER, C. K. 143, 144, V 10 No 3 Mar 96.

Utilization of surface water for drinking. SEDGWICK, Prof W. T. 33-39, disc 39-44, V 5 No 1 Sept 90.

Utilizing a spring as a source of supply. HAWES, L. E. 156-171, V 11 No 2 Dec 96.

Uvella, the worst infusorian in water. FORBES, F. F. 91, 92, V 6 No 2 Dec 91.

Value of water as an asset: query. 270, V 11 No 3 Mar 97.

Valve examination: disc. 70, 71, V 1 No 1 Sept 86.

Valves, Relief or safety.

BABCOCK, S. E. Use in water-works distribution system. 57-63, V 3 No 1 Sept 88.

COFFIN, F. C., and others. Pressure reducing valves. 142-145, V 17 No 2 June 03.

Velocity of water in 36-inch and 30-inch compound pipe. Diags of velocity curves. PORTER, Prof DWIGHT. 189-194, V 8 No 4 June 94.

Venner, John. Municipal use and waste of water. 268-271, V 17 No 3 Sept 03; disc 374-377, V 17 No 4 Dec 03.

Venturi meter.

HERSCHEL, C. Use in E Jersey Water Co's, Newark Water Works. 29, 30, diag 33, V 8 No 1 Sept 93.

HOLDEN, H. G. Test at Worcester. 159, V 12 No 3 Mar 98.

N E W W A Com on fire protection. 295, disc 296-314, V 16 No 4 Dec 02.

ROBERTSON, R. A. Diags and ill. 32-42, disc 43-47, V 7 No 1 Sept 92.

Vermont water supplies.

MOAT, C. P. Table. 514-521, V 15 No 6 Dec 01.

SEDGWICK, Prof W. T. Burlington, Vt. 167-183, V 10 No 3 Mar 96.

Vertical compound pumping engine, E. P. Allis Co. See Pumping engines.

Vigilance, Eternal, the price of good water. CHACE, G. F. 147-150, V 9 No 3 Mar 94.

Virchow and Devonshire processes. DROWN, Prof T. M. Filtration. 81, 82, V 5 No 2 Dec 90.

Walker, Charles K., Pres N E W W A. Portrait. Front, V 17 No 1 Mar 03.

Cement pipes. 53, 54, V 5 No 1 Sept 90.

Control and management of service pipes: disc. 19-22, V 2 No 1 Sept 87.

Excessive consumption of water. 237, 238, V 9 No 4 June 95.

Fire protection for manufacturing establishments: disc. 176-179, V 7 No 3 Mar 93.

Frozen hydrants: Manchester, N H. 13, 14, V 2 No 1 Sept 87.

Laying a main on Merrimac river bottom, etc. 220, V 7 No 4 June 93.

Manchester, N H, high service. Ills. 66-68, 68-75, V 10 No 1 Sept 95.

Manchester, N H, service gate boxes. 341, 342, disc 343, V 11 No 4 June 97.

Plugs. 220, V 7 No 4 June 93.

Private fire supply charges and control of supply. 407, 408, 420, V 15 No 5 Sept 01.

Stave pipe first used in Manchester, N H, in 1874. 248, 287, V 13 No 4 June 99.

Thawing frozen service pipes. 220, V 7 No 4 June 93.

Use of water from hydrants. 143, 144, V 10 No 3 Mar 96.

Water meter registration. 61-64, V 5 No 1 Sept 90.

Walking beam in S S "Puritan." HAWES, W M. 163, 164, V 3 No 4 June 89.

Waltham Water Works, Mass.

DEAN AND MAIN. Test of new pumping engine. 171-173, V 14 No 2 Dec 99.

FULLER, F. L. Covered supply well. 255, V 14 No 3 Mar 00.

Well to supply Waltham: diag. 182-184, V 6 No 4 June 92.

JOHNSON, F. P. Basin and well covering. Diags. 120-122, disc 123-129, V 8 No 3 Mar 94.

WINSLOW, G. E. 118-120, V 8 No 3 Mar 94.

Wannacomet Water Works. *See* Nantucket, Mass.

Ward joint pipes used for laying pipe under river. 135, 136, 139, V 5 No 3 Mar 91.

Ware Water Works, Mass. FULLER, F. L. 49-62, disc 62, 63, V 2 No 1 Sept 87.

Warren chemical pump. WESTON, E. B. Ill. 341, V 14 No 4 June 00.

Warren filter. Pittsburg plant, Pa. KNOWLES, MORRIS. Ill. 162-167, V 15 No 2 Dec 00.

Warsaw Water Works, Russia. SEDGWICK, Prof W. T. Covered filter. Plate. 115, V 7 No 2 Dec 92.

Washington, William d'H. Tenement-house water consumption, N Y. 236-238, V 9 No 4 June 95.

Waste heat engines. MILLER, E. F. 44-50, disc 50, 51, V 17 No 1 Mar 03.

Waste of water.

BALDWIN, C. H., and others. Meters as detectors. 34-42, trans 83.

BRACKETT, DEXTER. Water waste. 56, 57, V 1 No 1 Sept 86.

Discussion of D. Brackett's paper. 10-17, V 1 No 2 Dec 86.

COOK, B. I. Detection. 22-24, V 7 No 1 Sept 92.

ELLIS, G. A. Water waste and leakage. 38-40, trans 83.

HASKELL, J. C. Reduction of. 231-233, disc 233-239, V 9 No 4 June 95.

In winter: disc. 3-5, V 2 No 4 June 88.

NEVONS, HIRAM. Causes and prevention. 27-29, disc 30-47, trans 83.

THOMSON, JOHN. Comparison of cost of meters and loss of water. 58-67, V 8 No 2 Dec 93.

VENNER, JOHN. Municipal use and waste of water. 268-271, V 17 No 3 Sept 03; disc 374-377, V 17 No 4 Dec 03.

Water a medium of contagion. ABBOTT, Dr S. W. 25, 26, V 2 No 4 June 88.

Water analysis. *See* Analysis.

Water as an asset: query. 270, V 11 No 3 Mar 97.

Water-borne diseases, cholera, typhoid, malaria, etc. SMITH, Dr T. 203-214, disc 214-225, V 10 No 4 June 96.

Water consumption. *See* Consumption of water.

Water discharge from and through pipes: formulæ. 26, 27, V 1 No 2 Dec 86.

Water, Effect of storage on. STEARNS, F. P. 115-125, V 5 No 3 Mar 91.

Water filters. See Filters.

Water filtration. See Filtration.

Water gates. See Gates.

Water hammer.

FARNHAM, E. E. Experiences with, at Sharon, Mass. 56, 57, disc 57-59, V 6 No 1 Sept 91.

GIBBS, H. F. Effect on service pipes, Natick, Mass. 171, V 16 No 3 Sept 02.

HANCOCK, J. C. Effect on main pipes and remedy. 11, disc 11-14, V 5 No 1 Sept 90.

MANNING, G. E. Disc. 135-138, V 16 No 2 June 02.

NOYES, A. F. Discussion. 72-81, V 1 No 1 Sept 86.

PERRY, F. G., and others. Detection by recording pressure gage. 257-259, V 10 No 4 June 96.

WINSLOW, G. E. Effect on cement-lined pipe. 191-194, disc 195, 196, V 4 No 4 June 90.

Water in Japan. CHAPLIN, W. S. 20-26, V 1 No 2 Dec 86.

Water in some of its higher relations, geological and political. BEACH, Rev D. N. 133-142, V 3 No 3 Mar 89.

Water meter registration. WALKER, C. K. 61-64, V 5 No 1 Sept 90.

Water meter, The. Verses. LAYING, J. B. 69, V 1 No 1 Sept 86.

Water meters. See Meters.

Water pipe trenches v good roads. MCCLINTOCK, W. E. 71-77, V 8 No 2 Dec 93.

Water pipes. See Cast-iron; Cement-lined; Stave; Steel; Stone; Tim-lined; and Wood pipes.

Water power in streams, Methods of estimating loss of. HASTINGS, L. M. Diags and tables. 195-201, V 7 No 4 June 93.

Water purification. See Filters; Filtration; Oxidation; and Ozonization.

Water ram. Waltham Water Works, Mass: experience. WINSLOW, G. E. 493-499, V 15 No 6 Dec 01.

Water rates.

Classification: Uniform methods of. N E W W A committee appointed. 15, 16, V 1 No 1 Sept 86; 18, V 2 No 1 Sept 87. Report of N E W W A committee. 32-42, disc 42-44, V 2 No 1 Sept 87; 9, 10, V 5 No 1 Sept 90; 39-43, disc 43-47, V 6 No 1 Sept 91.

Collection of:

CHACE, G. F. Friction in collecting meter rates. 44-50, V 4 No 1 Sept 89.

A rumpus in collecting meter rates, and causes and consequences. Taunton, Mass. 230-237, disc 238, 239, V 14 No 3 Mar 00.

CHASE, J. C. A little talk about water rates. 174-179, V 17 No 2 June 03.

COFFIN, F. C. Financial consideration and adjustment of. Tables. 71-81, V 11 No 1 Sept 96.

- CRANDALL, F. H. Methods of assessment and collection of water rates. 133-143, disc 143-150, V 14 No 2 Dec 99.
- HATHAWAY, J. H. Methods of collecting water rates. 68, 69, disc 69-71, V 2 No 1 Sept 87.
- HOLDEN, H. G. Inequalities in. 213-215, disc 215-218, V 4 No 4 June 90.
- KNAPP, L. H. Collection of rates from city departments, Buffalo, N Y. 211, 212, V 14 No 3 Mar 00.
- Water service and fire protection in theatres.** GERHARD, W. P. 77-92, V 9 No 2 Dec 94.
- Water stealing: Experiences of.** KIMBALL, G. A. 187-190, V 4 No 4 June 90.
- Water supplies.**
- BABCOCK, S. F. Aëration by natural canals and low dams. 35-43, disc 43, 44, V 3 No 1 Sept 88.
- BRACKETT, D. At Boston fire, 28 Nov 89. Map. 182-185, disc 186, 187, V 4 No 4 June 90.
- Burlington, Vt. SEDGWICK, Prof W. T. 167-183, V 10 No 3 Mar 96.
- CATE, E. W., and others. Applications for — refusal — and taxation: disc. 32, 33, V 1 No 1 Sept 86.
- CHACE, G. F. Eternal vigilance the price of good water. 147-150, V 9 No 3 Mar 94.
- Sixteen-inch direct river pipe and effect on supply. 179-181, V 6 No 4 June 92.
- European. HAZEN, ALLEN. 109-121, disc 122-124, V 9 No 2 Dec 94
- FITZGERALD, D. Amount of rainfall available for. 41-48, disc 48-54, V 1 No 1 Sept 86.
- FORBES, F. F. Driven wells as source of supply. 141, 142, disc 142-144, V 5 No 3 Mar 91.
- FREEMAN, J. R. For fires. 49-77, disc 77-81, V 7 No 1 Sept 92; disc 152-164, V 7 No 3 Mar 93.
- GOODNOUGH, X. H. Public, Systematic examination of. 65-78, disc 78-81, V 14 No 1 Sept 99.
- HALL, Hon J. O. Duties of municipalities regarding water supply. 9-17, disc 17-20, V 17 No 1 Mar 03.
- Reciprocal obligations of management and the community. 338-348, V 17 No 4 Dec 03.
- HASKELL, J. C. Pure water from a surface supply. 137-144, disc 144-155, V 11 No 2 Dec 96.
- For fires. 47, 48, V 7 No 1 Sept 92.
- HAWES, L. E. Utilizing a spring. 156-171, V 11 No 2 Dec 96.
- HAZEN, ALLEN. Lakes as sources of supply. 163-166, V 10 No 3 Mar 96.
- In adjoining towns: legality of supplying questioned. 197, 198, V 0 No 4 June 95.
- JACKSON, J. F. Relation of great ponds to supplies. 203-208, V 3 No 4 June 89.

- KIERSTED, W. For small western cities. 83-90, V 5 No 2 Dec 00.
- Lynn, Mass. HASKELL, J. C. 55-63, disc 63, 64, V 10 No 1 Sept 95.
Mass surface water supplies. 79-84, V 13 No 2 Dec 98.
- Mass Metropolitan. NOYES, A. F. Diags. 117-129, V 10 No 2 Dec 95.
- MILLS, H. F. Typhoid fever and. Tables. 149-156, disc 156-160, V 5 No 4 June 91.
- Nashua, N H. HOLDEN, H. G. Ills. 249-255, V 16 No 4 Dec 02.
- New Bedford, Mass. WOOD, EDMUND. Diags and ill. 202-219, disc 219-225, V 11 No 3 Mar 97.
- New Orleans, La. WESTON, R. S. 157-171, disc 171-173, V 17 No 2 June 03.
- NILES, Prof W. H. As affected by variations in climate and weather. 74, 75, disc 75-78, V 5 No 2 Dec 00.
- NOYES, A. F. From driven wells. 19-26, V 1 No 4 June 87.
- Provincetown, Mass. HAWES, L. E. Map. 285-290, disc 291-293, V 11 No 4 June 97.
- Salem, Mass. Wenham lake water supply. HURLEY, JOHN. 272, 273, V 11 No 3 Mar 97.
- SEDGWICK, Prof W. T. Organisms causing unpleasant odors and tastes. 54-64, V 14 No 1 Sept 99.
- STEARNS, F. P. Sources, Selection of. Diags and tables. 102-127, disc 128-138, V 6 No 3 Mar 92.
- SWAIN, Prof G. F. Influence of forests upon rainfall, etc. 11-26, V 1 No 3 Mar 87.
- Vermont. MOAT, C. P. Analytic tables. 514-521, V 15 No 6 Dec 01.
- Waltham, Mass. WINSLOW, G. E. 118-120, V 8 No 3 Mar 94.
- Water tank, Fall River, Mass. KIERAN, PATRICK. 26, 27, disc 27-32, V 2 No 1 Sept 87.
- Water towers. *See* Standpipes and Elevated Tanks.
- Water tube boilers *v* horizontal tubular boilers. REYNOLDS, I. H. Disc. 200-202, V 13 No 3 Mar 99.
- Water used in back filling trenches. HAMMATT, E. A. W., and others. 168-170, V 12 No 3 Mar 98.
- WHIPPLE, G. C., and JACKSON, D. D. Asterionella in, and effect on. Diags. 1-23, disc 23-25, V 14 No 1 Sept 99.
- Water supply, Metropolitan.** NOYES, A. F. Nashua river watershed and reservoir. Map and diags. 117-129, V 10 No 2 Dec 95.
- Water waste.** *See* Waste of water, also Leakage.
- Water works.**
Boston.
BRACKETT, D. Cleaning main, 1886-87. 341-344, V 13 No 4 June 99.
LEARNED, W. F. Ashland basin, No 4, etc. 3-8, disc 8-11, V 2 No 2 Dec 87.
Buffalo, N Y. KNAPP, L. H. Ills. 206-212, V 14 No 3 Mar 00.

- Burlington, Vt. CRANDALL, F. H. Map and ills. 150-159, disc 159-166, V 10 No 3 Mar 96.
- PARKER, F. H. High service motor. 63-66, disc 66-68, V 2 No 1 Sept 87.
- Cambridge, Mass. HASTINGS, L. M. Diags and ills. 121-132, disc 132-136, V 11 No 2 Dec 96.
- Cohasset, Mass. TOWER, D. N. 189-193, disc 193, 194, V 12 No 3 Mar 98.
- Fairhaven, Mass. NYE, J. K. Diags. 175-180, disc 180-182, V 8 No 4 June 94.
- Flushing, N Y. ROULLIER, G. A. Advisability of meters. 56-58, disc 59-65, V 5 No 1 Sept 90.
- Franklin, N H. FULLER, F. L. Diags. 82-87, V 7 No 1 Sept 92.
- Glasgow, Scotland. GALE, J. M. Tables. 240-251, V 14 No 3 Mar 00.
- Lawrence, Mass. MILLS, H. F. Filter and results. 44-55, disc 56, 57, V 9 No 1 Sept 94.
- ROGERS, H. W. 6-9, V 1 No 2 Dec 86.
- Lowell, Mass. HOLDEN, H. G. 73-80, trans 85.
- Manchester, N H. WALKER, C. K. 66-68, V 10 No 1 Sept 95; 341-343, V 11 No 4 June 97.
- Marlborough, Mass. STACY, G. A. Ills. 139-150, V 16 No 2 June 02.
- Metropolitan.
- BRACKETT, D. Pipes. 325-332, V 13 No 4 June 99.
- HOWARD, J. L. Middlesex Fells reservoir. 20-32, V 15 No 1 Sept 00.
- LOCKE, W. W. Sanitary inspection. 483-492, V 15 No 6 Dec 01.
- OLMSTED, F. L. Landscape problems in Middlesex Fells. 272-287, V 15 No 3 Mar 01.
- SANDO, W. J. Pumping machinery. 290-304, V 15 No 4 June 01.
- Trial of thirty-million-gallon pumping engine. 232-243, V 15 No 3 Mar 01.
- SAVILLE, C. M. Reservoir and standpipe construction (Forbes hill). 177-222, V 16 No 3 Sept 02.
- Visit of N E W W A, 12 Sept 02. 394-398, V 16 No 4 Sept 02.
- Milford, Mass. NORTHROP, F. L. 262-264, V 10 No 4 June 96.
- Montreal. JANIN, GEORGE. History, etc. 272-283, V 17 No 3 Sept 03; disc 378-382, V 17 No 4 Dec 03.
- LESAGE, T. W. Service boxes. 284-287, V 17 No 3 Sept 03.
- Nantucket, Mass. Wannacomet. CODD, W. F. 171-174, V 8 No 4 June 94.
- Connecting lead services. 187, 188, V 9 No 3 Mar 95.
- New Bedford. COGGESHALL, R. C. P. Temporary dam. 200, 201, V 3 No 4 June 89.
- WOOD, EDMUND. 202-219, disc 219-225, V 11 No 3 Mar 97.
- New Haven, Conn. TAYLOR, L. A. Woodbridge dam. 51-56, V 6 No 1 Sept 91.
- New London, Conn. RICHARDS, W. H. 148-151, V 7 No 3 Mar 93.

New Orleans, La. WESTON, R. S. 157-171, disc 171-173, V 17 No 2 June 03.

Newark, N J, East Jersey Water Co. HERSCHEL, C. Diags. and tables. 18-39, V 8 No 1 Sept 93.

Newport, N H. TAYLOR, L. A. 145-149, disc 149-152, V 12 No 3 Mar 98.

Newton, Mass. HYDE, H. N. Flushing mains. 81, trans 85.

Portsmouth, N H. AYERS, J. O. 67-69, disc 69, 70, V 13 No 1 Sept 98.

Quincy, Mass. TAYLOR, L. A. Dam. 167-174, V 3 No 4 June 89.

Reading, Mass. BANCROFT, L. M. 294-300, V 11 No 4 June 97.

Richmond, Va. BOLLING, C. E. 39-43, disc 43, 44, V 4 No 1 Sept 89.

Rochester, N Y. KUICHLING, E. 138-143, V 13 No 2 Dec 98.

St John, N B. MURDOCK, W. 147-151, V 13 No 2 Dec 98.

Cleaning a main. 333-341, disc 341-344, V 13 No 4 June 99.

Wooden joints. 34-37, V 15 No 1 Sept 00.

St Louis, Mo. DEAN, F. W. 172-194, V 11 No 2 Dec 96.

Syracuse, N Y. HILL, W. R. Laying pipe in Skaneateles lake. 40-45, V 8 No 1 Sept 93.

Taunton, Mass. BILLINGS, W. R. Street main flushing. 85-87, trans 85.

Waltham, Mass. JOHNSON, F. P. Diags. 120-122, disc 122-129, V 8 No 3 Mar 94.

Ware, Mass. FULLER, F. L. 49-62, disc 62, 63, V 2 No 1 Sept 87.

Waterbury, Conn. WHITLOCK, F. W. Gravity system. 80, V 5 No 2 Dec 90.

Webster, Mass. FULLER, F. L. Tables and plan. 240-247, V 9 No 4 June 95.

Woonsocket, R I. COOK, B. I. 20-26, disc 27-35, V 12 No 1 Sept 97.

Water-works construction, etc.

BABCOCK, S. E. Use of safety valves in. 57-63, V 3 No 1 Sept 88.

GOWING, E. H. Standard specifications. 168-171, disc 171-178, V 6 No 4 June 92.

HILL, W. R. Things to be done in construction of distributing systems. 36-39, disc 40-48, V 13 No 1 Sept 98.

KINGSLEY, C. W. Construction and maintenance. 127-133, V 3 No 3 Mar 89.

WILLIAMS, G. S. Design of distribution systems 97-101, disc 101-115, V 14 No 2 Dec 99.

Water-works management.

ALLIS, S. M. Economy in. 161-163, V 6 No 4 June 92.

COFFIN, F. C. Financial management: statistics and diagrams. 63-86, disc 87-98, V 11 No 1 Sept 96.

DARLING, EDWIN. Practical details of. 7-11, disc 11-18, V 2 No 1 Sept 87.

Water works, Municipal.

HALL, F. E., and others. Public and private: disc. 17-24, V 4 No 1 Sept 89.

MATTHEWS, NATHAN. Municipal ownership. 1-5, V 9 No 1 Sept 94.

- TUBBS, J. N. Reasons why motor power should not be furnished from. 152-155, V 6 No 4 June 92.
- Water-works records. GLOVER, A. S. Records. 69-79, V 4 No 2 Dec 89.
- Water-works reports. BILLINGS, W. R., and COGGESHALL, R. C. P Uniformity in preparation: suggested by N E W W A. 118-140 disc 141-148, trans 85; 66-73, trans 84.
- Water-works statistics. See Statistics of Water-works.
- Waterphone, Bell, for detection of leakage. Users' experiences. 73-75 trans 84.
- Watersheds.
- FITZGERALD, D. Sudbury and Cochrane, capacity in drought. 12-21, tables 22-32, V 2 No 2 Dec 87.
- LARNED, E. S. Improvement, by drainage of swamps. Ills. 36-44, disc 44-50, V 16 No 1 Mar 02.
- MIDDLETON, R. E. Areas and sanitary districts coterminous. 119-129, disc 129-137, V 13 No 2 Dec 98.
- Watertown, Mass. CRAFTS, N. H. Report on cast-iron pipe. 175-196, V 3 No 4 June 89.
- Weather and climate variations as affecting water supply. NILES, Prof W. H. 74, 75, disc 75-78, V 5 No 2 Dec 90.
- Webster Water Works, Mass. FULLER, F. L. 240-247, V 9 No 4 June 95.
- Weights of Boston gas mains. GOULD, J. A. Tables. 110, V 16 No 2 June 02.
- Weights of cast-iron pipes.
- METCALF, LEONARD. Variation diagram. 116, 117, tables A B 122, 123, V 16 No 2 June 02. N E W W A tables. 343, V 16 No 4 Dec 02.
- NOYES, A. F. 28-51, diags. 154-159, trans 85.
- Weisbach, curved pipe experiments. 114, V 14 No 2 Dec 99.
- Weld, F. Floyd. Died 28 June 90. Obituary 64, V 6 No 1 Sept 91.
- Well covering and basin at Waltham Water Works, Mass. JOHNSON, F. P. 120-122, disc 123-129, V 8 No 3 Mar 94.
- Wellesley covered reservoir. COFFIN, F. C. 255-261, diag after 284, V 14 No 3 Mar 00.
- Wells, George L. Improved Wyckoff water pipe. Ills. 288-303, V 13 No 4 June 99.
- Wells, Hon Henry J. Remarks at dinner of Amer W W A and N E W W A, 21 Apr 85. 211, 212, trans 85.
- Wells light for night work and melting lead joints. GARDNER, E. P. 168-170, V 7 No 3 Mar 93.
- Wells.
- Artesian. CHACE, G. F. Taunton experience. 222, 223, disc 223, 224, V 4 No 4 June 90.
- Collecting. FULLER, F. L. Waltham, Mass. Diag. 183, 184, V 6 No 4 June 92.
- Driven.
- BALL, P. Use in various soils. 29-32, disc 33, 34, V 3 No 1 Sept 88.

- BOWERS, GEORGE. Underground water. 127-132, disc 132-137, V 17 No 2 June 03.
- DOANE, A. O. 133, 134, V 17 No 2 June 03.
- FORBES, F. F. As a source of water supply. 141, 142, disc 142, 144 V 5 No 3 Mar 91.
- Brookline, Mass. 195-199, disc 199-201, V 11 No 3 Mar 97.
- NOYES, A. F. 19-26, V 1 No 4 June 87.
- TIDD, M. M. Experience with. 79-81, V 1 No 1 Sept 86.
- TOWER, D. N. Brookline system. 193, 194, V 12 No 3 Mar 98.
- Tube.
- BOWERS, GEORGE. Lowell, Mass. Experiences. 67-76, V 9 No 2 Dec 94.
- Result of experiment. 30-33, disc 33-35, V 13 No 1 Sept 98.
- Second plant. 226-229, V 10 No 4 June 96.
- BOYCE, W. C. Reliability of tests for water supply (Kingston, Mass). 26-28, V 3 No 1 Sept 88.
- Wenham lake water supply for Salem, Mass.** HURLEY, JOHN. 272-274, V 11 No 3 Mar 97.
- West Los Angeles Water Co.** ADAMS, A. L. Astoria gravity pipe line. 253, V 13 No 4 June 99.
- Weston, Edmund B.**
- Mechanical filtration of water. Diags. 333-353, disc 353-362, V 14 No 4 June 00.
- Providence, R I, separate high pressure fire service system. Diags. 85-90, disc 91-93, V 13 No 2 Dec 98.
- Providence, R I, street main flushing. Diag. 87, 88, trans 85.
- Weston, Robert Spurr.**
- Cristatella in storage reservoir at Henderson, N C. Map and diags. 20-26, disc 27-29, V 13 No 1 Sept 98.
- Filter plants, New Albany, Ind, and Louisville, Ky. 15-18, V 13 No 1 Sept 98.
- Turbidity determinations in New Orleans. 27-31, V 17 No 1 Mar 03.
- Water supply of New Orleans and its improvement. 157-171, disc 171-173, V 17 No 2 June 03.
- What a water supply engineer can do.** TRYON, JAMES. 93-102, V 9 No 2 Dec 94.
- What we don't know about fuel.** ATKINSON, EDWARD. 180-195, disc 195-200, V 17 No 2 June 03.
- Wheeler, William.** Ashland, Wis, covered sand filter. Diag and tables. 301-327, disc 327-329, V 11 No 4 June 97.
- Whidden, Hosea F.** Died 31 Jan 88. Obituary 36, V 2 No 3 Mar 88.
- Whipple, George C.**
- Growth of organism in Boston water pipes. Diags and tables. 1-17, disc 17-19, V 12 No 1 Sept 97.
- Microscopy of drinking water. 59-62, V 14 No 1 Sept 99; reviewed by Prof SEDGWICK.

- Raphidomonas (infusorian) in Lynn water. Ill. 348-357, V 11 No 4 June 97.
- Relation of light to the growth of diatoms. Diags and tables. 1-24, disc 25, 26, V 11 No 1 Sept 96.
- Temperature of surface waters and its effect on growth of micro-organisms. 202-216, disc 216-222, V 9 No 4 June 95.
- Thermophone. Diag. 215-222, V 9 No 4 June 95.
- Whipple, George C., and Jackson, D. D.** Asterionella; its biology, chemistry and effect on water supplies. Diags. 1-23, disc 23-25, V 14 No 1 Sept 99.
- Whitlock, Frank W.** Gravity system of Waterbury, Conn. 80, V 5 No 2 Dec 90.
- Whitney, John C.**
Advisability of use of water meters: disc. 21, V 6 No 1 Sept 91.
Care of a water meter. 106, 107, disc 107, 108 V 9 No 2 Dec 94.
Pits in block tin service pipes. 88, V 6 No 2 Dec 91.
Report of N E W W A committee on classification of rates. 39-43, disc, 43-47, V 6 No 1 Sept 91.
Testing of water meters: disc. 86, 87, V 3 No 2 Dec 88.
- Whittemore, W. P.** High water alarm for reservoirs and tanks: Diag. 21-23, disc 23-25, V 3 No 1 Sept 88.
- Why I favor use of cement pipe.** CRILLY, P. F. 50-52, disc 53-56, V 5 No 1 Sept 90.
- Wilcox, William C.** Uniformity in water-works reports: disc. 141-143, trans 85.
- Wilder, Frederick W.** Private water-works: disc. 22, V 4 No 1 Sept 89.
- Williams, Gardner S.**
Design of water-works distribution systems. 97-101, disc 101-115, V 14 No 2 Dec 99.
Electrolysis of pipes by trolley system (Detroit). 44, 45, V 10 No 1 Sept 95.
Meter registration: disc. 100-107, V 10 No 2 Dec 95.
- Willimantic Water Works, Conn.** FANNING, J. T. Horizontal turbines and pumps. Ill. 40, V 1 No 1 Sept 86.
- Winchester Water Works, Mass.** COFFIN, F. C. Oil pumping engine. 212-214, V 13 No 3 Mar 99.
- Winship, Horace B.** Died 8 Nov 99. Obituary 193, V 14 No 2 Dec 99; 200, V 15 No 2 Dec 00.
- Winslow, Charles-Edward Amory.**
Bacteriological analysis of water. 459-477, disc 477-482, V 15 No 6 Dec 01.
Typhoid epidemic in Ithaca, N Y, and Lawrence, Mass. etc. 171-173, V 17 No 2 June 03.
- Winslow, George E.**
Back filling trenches. 173, V 6 No 4 June 93.
Depth of lead in pipe joints. 25, 26, V 5 No 1 Sept 90.

- Effect of water hammer on cement-lined pipe. 191-194, disc 194-196, V 4 No 4 June 90.
- Electrolysis of water pipes. 39, 40, V 9 No 1 Sept 94; 42-45, V 10 No 1 Sept 95.
- Frozen hydrants. 12, V 4 No 1 Sept 89; 163, V 6 No 4 June 92.
- Hose outlets on hydrants. 26, 27, V 5 No 1 Sept 90.
- Hydrant sizes. 94, 95, V 2 No 1 Sept 87.
- Service pipes. 21, V 2 No 1 Sept 87. Lead. 25, 26, V 6 No 1 Sept 91.
- Sizes of main pipes. 19, V 5 No 1 Sept 90.
- Use of air in pressure gages. 248, V 9 No 4 June 95.
- Use of water in back filling trenches. 167-169, V 12 No 3 Mar 98.
- Waltham, Mass, water supply. 118-120, V 8 No 3 Mar 94.
- Water ram (Waltham, Mass). 493-498, disc 498, 499, V 15 No 6 Dec 01.
- Wiped and cup joints: comparative value.** BILLINGS, W. R., and others. Disc. 71, 72, V 1 No 1 Sept 86.
- Wood, Edmund.** Further water supply of New Bedford, Mass. Diags, ill. 202-219, disc 219-225, V 11 No 3 Mar 97.
- Wood pipe.**
- ADAMS, A. L. Stave pipe. Diags and ill. 247-287, V 13 No 4 June 99.
- GARRETT, JESSE. History and ill. 32-36, V 11 No 1 Sept 96.
- HALL, F. E. Merits of various kinds of main. 108, trans 85.
- Woodbridge, Conn, dam of New Haven Water Works.** TAYLOR, L. A. Diag. 51-56, V 6 No 1 Sept 91.
- Woodbury, Governor of Vermont.** Address to N E W W A, 11 Sept 95. Burlington, Vt. 3, 4, V 10 No 1 Sept 95.
- Wooden joints in cast-iron water mains.** MURDOCK, WILLIAM. (St John, N B.) 34-37, V 15 No 1 Sept 00.
- Woolen mill wastes polluting streams.** CLARK, H. W. 502-506, V 15 No 6 Dec 01.
- Woonsocket Water Works, R I.**
- COOK, B. I. Reservoir and dam No 3. Diag. 20-26, disc 27-35, V 12 No 1 Sept 97.
- Standpipes. 124-126, disc 127-132, V 14 No 2 Dec 99.
- Woonsocket service box. Ill. 308, V 15 No 4 June 01.
- TAYLOR, L. A., and others. 150, 151, V 12 No 3 Mar 98.
- Worcester distributing reservoir and dam.** HASSAM, W. E. 153-159, V 12 No 3 Mar 98.
- Worms tile filter, Pittsburg, Pa.** KNOWLES, MORRIS. Ill. 176-178, V 15 No 2 Dec 00.
- Worthington, Charles C.** Latest designs in Worthington pumping machinery. Ills. 229-241, V 13 No 3 Mar 99.
- Worthington high-duty pumping engine.** Ill. 96, V 8 No 2 Dec 93.
- Wrought-iron gas pipe.** BROWNELL, E. E. Electrolytic effect on. Ill. 370, V 14 No 4 June 00.
- Wrought-iron pipe for driven wells.** FORBES, F. F. Brookline, Mass. 199, V 11 No 3 Mar 97.

Wrought-iron pipe main: repairs on. TILDEN, J. A. 202, V 3 No 4
June 89.

Wyckoff improved water pipe. WELLS, G. L. Ills. 288-303, V 13
No 4 June 99.

Y branches for pipes.

BRACKETT, DEXTER. Diags and dimensions. Plate VIII. 78, V 8
No 2 Dec 93.

N E W W A Com on cast-iron pipe. Tables. 85, 86, V 17 No 1 Mar 03.

Yates, Richard R. Died 10 Sept 96. Obituary 72, V 12 No 1 Sept 97.

Young, Dr Thomas. (1808) Curved pipe experiments, based on Du Buat's.
113, V 14 No 2 Dec 99.

Zurich, Switzerland. SEDGWICK, Prof W. T. Sand filters. 115, 116,
V 7 No 2 Dec 92.



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